PAPERS AND PROCEEDINGS OF

THE ROYAL SOCIETY OF TASMANIA

Edited by M. R. Banks and M. J. Brown

and Published by the Society

Hobart

Tasmania

MUSEUM OF VICTORIA
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VOLUME 129

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VOLUME 129

ISSN 0080-4703

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Her Majesty the Queen

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His Excellency the Governor of Tasmania
General Sir Phillip Bennett AC, KBE, DSO

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Honorary Assistant Editor
Dr Steven Smith (to June)
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PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA
VOLUME 129

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Publication of this volume was generously supported by the Government of Tasmania and the University of Tasmania.

ROYAL SOCIETY OF TASMANIA

Annual Report for the Year 1994

The Council has the honour to present to members the following report on the activities of the Society during the year.

Council and Office Bearers

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Dr Mick Brown (from July)

President

His Excellency General Sir Phillip Bennett took the Chair as President of the Society at the Annual General Meeting of the Society and that of the Northern Branch. Sir Phillip also took the Chair at the meeting of 20 June, at which Dr Hugh Torrens, University of Keele, UK, former President of the British Society for the History of Science spoke on *Patronage and Problems: Joseph Banks and the Earth Sciences.* The President also chaired the Members Night of the Northern Branch in June. Lady Bennett accompanied Sir Phillip on these two occasions. Accompanied by Lady Bennett, the President joined members of the Society for the Christmas dinner on 14 December.

Deaths

The deaths of the following members are recorded with regret

Mr T.W. Archer
Mr R.M.H. Garvie
Mr N.J.B. Plomley

Obituaries

Mr T. Archer

Mr Archer, a member from 1976 to 1994, died May 1994. He was a regular attender of meetings of the Northern Branch and served on its Council in 1987-1988. He was also an active member of the National Trust and the Field Naturalist Club. Mr Archer was the last direct descendant of the Archer family who established *Woolmers* at Longford. He will be remembered for his interest in the restoration of colonial buildings in northern Tasmania including *Woolmers* and *Clarendon.*

Mr R.M.H. Garvie

Mr Garvie, who died 20 October 1994, in Hobart, was a member from 1956 to 1981, Junior Vice-President in 1967, Senior Vice-President in 1968 and a member of Council in 1969, 1970 and 1971.

Mr N.J.B. Plomley

Mr Brian Plomley, who died in Launceston on 8 April 1994, was Honorary Secretary of the Northern Branch from 1946 to 1949 and was awarded the Clive Lord Memorial Medal of the Society in November 1983. He contributed at least four papers to the Society's *Papers and Proceedings* on historical and anatomical topics. He was more widely known for his pamphlets and books on Tasmanian Aborigines and on French exploration of Tasmania. Prominent among the books on the Aborigines were *Friendly Mission* (1966) and *Weep in Silence* (1987), and on French exploration his book with Piard-Bernier, *The General* (1993).

Honours and Awards to Members

The Society congratulates Mrs Doone Kennedy, Lord Mayor of Hobart, on her appointment as Officer of the Order of Australia in the Australia Day Honours List in January 1994.

Membership

The membership is 475, an increase of 5 over the previous year, and is made up as follows:

	Southern	Northern	Total
Honorary Life Members	5	2	7
Life Members	22	10	32
Ordinary Members receiving *Papers and Proceedings*	244	52	296
Ordinary Members not receiving *Papers and Proceedings*	72	43	115
Associate Members	18	7	25
Total	361	114	475

Council Meetings

There were seven meetings of Council during the year. Of these one was a special meeting to determine Council's view on the future of the Tasmanian Herbarium. Council decided to recommend that, prior to any change in the administrative arrangements for the management of the Herbarium, the future of that body be the subject of a thorough and independent inquiry. The Premier was subsequently made aware of this recommendation.

A committee was set up by Council late in 1993 to develop a corporate strategic plan for the Society. This committee met three times during 1994 and produced a report which was accepted by Council in December. The report suggested a number of initiatives, implementation of some of which has commenced. Closer involvement in administration of the Society by members was seen as desirable and minor changes in administrative structure were recommended. Better communication between Council and members of the Society as a whole was also seen as desirable and some steps have been taken to achieve this. The assets of the Society were listed and the need for closer examination of some of these noted. Better utilisation of our assets is being considered.

Council has been kept informed by the Trustees of the Tasmanian Museum and Art Gallery of plans for re-development of the Museum and Art Gallery, possible because of the Customs House becoming available for Museum purposes. Council is negotiating with the Trustees on the provision of facilities for the Society within the re-organised complex. Preliminary plans have been made for the launching of a Royal Society of Tasmania Foundation in the first half of 1995. Council seeks strong support from members for this initiative.

Sesquicentenary of the Granting of the Royal Charter

The Society, founded in 1843, received the Royal Charter on 12 September 1844 and became the Royal Society of Van Diemen's Land for Horticulture, Botany and the Advancement of Science.

The Sesquicentenary of the granting of the Royal Charter was marked by an invitation from the President, Sir Phillip Bennett, to hold the Annual General Meeting at Government House. Over 80 members, from many parts of the State accepted this invitation and heard Professor Adrienne Clarke, Chief Executive CSIRO, deliver a stimulating address on *Science and Technology and Australia's Future.*

To close the Sesquicentenary year, over 80 members and guests joined the President and Lady Bennett at an enjoyable Christmas Dinner at the CSIRO Marine Laboratories, Hobart.

Grants to the Society

The Council received a general grant from the Tasmanian Government, through Arts Tasmania, of $2000 towards the Society's administration and promotion, and a special grant from the Tasmanian Government of $3000 towards the Society's publication program.

The University of Tasmania has provided an annual subvention of $3000 towards the publication costs of the *Papers and Proceedings of the Royal Society of Tasmania.*

Library

The year under review was again one which has seen gradual progress towards inclusion of the Library's records in the University Library database, and the accompanying reclassification and cataloguing of the associated material.

The analysis of the card shelf list against the database continues, with notes being made where items already exist. The recataloguing and reclassification process allows for such material to be readily transferred. At the same time, the current serials are being re-catalogued at a slow but steady rate which should see all current titles appearing in the on-line catalogue before older, now deceased, titles.

During the year, some surplus and weeded Library stock was sold as a separate exercise or via the University Library Book Sale. In total, a sum of approximately $600 was raised from the sale of this material.

An exchange viability survey was undertaken late in 1993, with 80 letters being despatched to exchange partners. The results of the survey revealed 25 terminated titles, 5 terminated exchange partnerships, and 28 renewed exchanges (apparently lapsed), whilst other exchanges were confirmed as active and viable.

Arrangements for periodical borrowing were revised during the year, with all borrowings now being channelled through the Library issue desk in the Morris Miller Library. This process allows for greater security of Royal Society collections, as all material is now checked by staff at the desk.

Binding of Royal Society titles was resumed in earnest during the year, after the reorganisation of University binding arrangements. A quota for binding is now allocated to the Royal Society as part of the Morris Miller allocation and, despite the need to bind somewhat thicker combined bibliographical volumes, the allocation should cope with the current serial receipts.

Staffing for the year remained as for 1993, with Graeme Rayner continuing as Royal Society Librarian, Mrs Carol Freeman as part-time assistant and Mrs Emilia Ward continuing to provide five hours each week of additional clerical support. The daily routines of the Library are now well established and the growing experience and ability of the clerical staff allows for much of the work to continue unsupervised. As always, the Reference staff in Morris Miller continue to provide user support at times when staff are absent from the Royal Society Library.

Volume 128 of the *Papers and Proceedings* was despatched to exchange partners during the middle of the year.

Further work was undertaken in the reorganisation of the Library's Rare Books collection which now occupies two rooms adjacent to the office. Material is now filed in more logical sequence, with folio and elephant folio material distinguished in the catalogue. Provision for a small consultation table in the larger of the two rooms now allows for supervised consultation of rare materials and greater monitoring of use.

The reclassification programme has resulted in a regular reshuffling of Library materials to accommodate titles being moved from the older sequences. There is a need for a concerted effort in compacting the old collection to create the maximum amount of space for the re-classified collection. Similarly, there is a degree of refiling and reorganisation necessary for the serials accessioning files as new cataloguing inevitably results in changed filing arrangements.

Statistics for the year are as follows, but it should be recorded that visitor and consultation figures are, in reality, more likely to be higher, as users often omit to sign the appropriate registers.

Visitors	235
Consultations	137
Loans (incl. ILL)	59

Overall the year has been one of steady progress and we look forward to further progress in 1995.

Publications

Towards the end of June, Volume 128 of the *Papers and Proceedings* was published. This volume contained the Annual Report for 1993 and 70 pages of technical papers. The papers, eight in number and involving 18 authors, dealt with topics such as botany and palaeobotany, plant ecology, animal ecology, zoology and micropalaeontology. Authors came from Tasmanian State Departments, the University of Tasmania and interstate.

Dr Steven Smith relinquished his post as Honorary Assistant Editor with the publication of Volume 128. Dr Smith took a significant part in the production of 12 volumes of *Papers and Proceedings*, including the volume on Macquarie Island, was one of the editors of *Aspects of Tasmanian Botany,* chief editor of *Tasmanian Wilderness — World Heritage Values* and editor of *Tasman Peninsula — Is history enough?* His very considerable contribution to the Society is gratefully acknowledged.

Dr M.J. Brown has assumed the mantle of Honorary Assistant Editor.

Production of volume 128 was assisted by Ms Alison Jones, who provided careful sub-editing, and Ms June Pongratz as expert typesetter and formatter.

Lectures

The following lectures were given at General Meetings during the year:

March 15 — (Annual General Meeting) "Science and technology and Australia's future" Professor Adrienne Clarke, Chairman, CSIRO

April 5 — "War and children (with special reference to the Gaza Strip)" Associate Professor Carey Denholm, Department of Education, University of Tasmania at Hobart

April 18 — "Computer aided drug design" Dr Brian Yates, Department of Chemisty, University of Tasmania at Hobart.

May 4 — "I've got a little list, They'll none of them be missed, They'll none of them be missed" Mr Bevan Rees, Architect, Hobart

May 16 — "Urban wildfires: Sydney, 94" Mr Jim Gould, Bushfire Research Unit, CSIRO Division of Forestry, Canberra

June 7 — "Professor L.F. Giblin his life and work" Hon Michael Field, Leader of the Opposition, Tasmanian Parliament

June 20 — "Patronage and problems — Joseph Banks and the earth sciences" Dr Hugh Torrens, President of the British Society of the History of Science

July 5 — "The importance of James Backhouse in the history of Van Dieman's Land in the 1830s" Dr W.N. Oats, Hobart

July 18 — "Modernism, mandates and mandarins" Associate Professor Richard Herr, Department of Political Science, University of Tasmania at Hobart

August 1 — "The Boyd Retrospective" Mr David Hansen, Senior Curator, Humanities, Tasmanian Museum and Art Gallery

September 6 — "Landcare issues in Australia" Ms Helen Alexander, National Facilitator, Landcare Australia,

September 19 — "What is ecotourism?" Ms Jane Foley, Department of Tourism, Sport and Recreation, Hobart

October 4 — "Melanoma" Dr Ian McColl, Hobart

October 17 — "Panel Discussion: Islands off southern Tasmania" Mr Nigel Brothers, Parks and Wildlife Services, Mr Ralph Bottrill, Mineral Resources, Tasmania, Dr Max Banks (Convener)

November — "Visual factors and reading ability" Mr Byron Harrison, Optometrist, Hobart

(Attendance at General Meetings ranged from 17 to 59).

Excursions and Functions

March — Excursion to distillery, Essential Oils Ltd, Gretna and *Rotherwood,* Ouse.

November — Visit to the Hyperbaric Chamber, Royal Hobart Hospital, Dr Peter McCartney
December — Christmas visit and dinner, CSIRO Marine Laboratories, Hobart

The programme of events for the year was arranged by a Programme Committee (Dr J. Thorne [Chair], Mr P.C. Stevenson, Mr S.M. Murrihy and Ms J. Fricker). The Society thanks the members of this Committee.

Northern Branch

Branch Council

Chairman	Mr Elvin H. Fist
Vice Chairman	Mr John Kolkert
Past Chairman	Mrs Mary Cameron
Honorary Secretary	Mr Chris Tassell
Honorary Treasurer	Mr Bruce Pike
Council Members	Mr Athol Beswick
	Ms Alison Green
	Ms Judith Hollingsworth
	Mr Alan Orr
	Mr Mike Temple-Smith

The Council met four times during the year

Meetings and Lectures
March 11 — Annual General Meeting chaired by His Excellency, General Sir Phillip Bennett, Governor of Tasmania. "Modern History of Railways in Tasmania" Dr Neil Otway, General Manager, AN Tasrail.
April 8 — (Combined meeting with the Launceston Historical Society) Princes Square Fountain, Dr Eric Ratcliff
May 6 — "Proceedings of a Museum's Director" Mr D. Gregg, formerly Director of the Tasmanian Museum and Art Gallery
June 9 — Members Night:
"Swan Island" Mrs D. Girvan
"Colonial Doorways" Mr A. Orr
"Nitrogen Nutrition" Dr T. Fist
"It Is All Over Now" Mr J. Kolkert.
His Excellency, General Sir Phillip Bennett, Governor of Tasmania, chaired the meeting
July 8 — "Zoological Research" Dr B. Smith, Honorary Associate of Zoology, Queen Victoria Museum
August 5 — "The Family and Public Health" Professor Alex Thompson, Professor of Community Health, University of Tasmania at Launceston
September 2 — "Between Tasman and Cook" Professor C. McKnight, Professor of Humanities, University of Tasmania at Launceston
October — "Russian Dinosaur Exhibition" Mr C. Tassell, Director of the Queen Victoria Museum
December — Members Night
"Blood Transfusion in the 1990s" Christine Beswick, haemotologist, Pathology Department, Launceston General Hospital
"History of Maria Island" Doreen Girvan
"C.S. Lewis" Mr Stan Payne
"Over-population, Over-consumption and Economics" Dr Colin Butler

Excursions
July — Invermay Railway Yards tour conducted by Mr Chris Tassell, Director Queen Victoria Museum
October — Tamar Island tour conducted by Dr Robert Green, formerly head zoologist at Queen Victoria Museum
November — Weather Station at Launceston Airport, Western Junction, conducted by officers of the Bureau of Meteorology

Nominees to Other Bodies

The Council elected Professor D.M. Stoddart and Dr A.V. Brown to serve on the Board of Trustees of the Tasmanian Museum and Art Gallery for 1994. Professor Stoddart resigned his position upon his appointment to an interstate position in September. Professor J.B. Reid was appointed in his place. These Trustees report on the year's activities:

1994 was a year of consolidation where the work of the past two years in the areas of exhibition, sponsorship, heritage preservation and computerisation of the collection made significant advances.

There were 36.8 (Full Time Equivalent) Staff in 1994. New appointments included Mr David Hansen as Co-ordinating Curator (Art and Humanities) and Senior Curator of Art, and Andrew Rozefeld, Phanerogamic Botanist.

Dr Christa Johannes, retiring from her previous position as Curator of Art, was appointed Curator (Education) part-time, enabling the Museum to partially reinstate its education program.

Mr Tim Knight, Secretary of the TMAG, was transferred to the position of Bursar at Sorell District High School in February 1994. His eighteen years of service to the TMAG and the Royal Society are gratefully acknowledged.

Dr Kantvilas, Head of the Herbarium, was awarded a Alecto-Banks Scholarship by the Royal Society London to study for three months at the British Museum of Natural History. The Curator (Geology), Noel Kemp, was awarded a National Geographic Society Research Grant to investigate fossil deposits in Queensland. Dr Philip Thomson was appointed Honorary Curator of Medical History. He was awarded a Churchill Fellowship for 1995.

Honorary Curators and volunteers continue to give invaluable support to the Tasmanian Museum and Art Gallery. Programmes have included assisting in specialist curatorial work, data entry, cataloguing, exhibition preparation, collection maintenance, fund raising and guiding at exhibitions.

The public consultation program of the Concept Plan for the Strategic Re-Development of the TMAG Precinct was publically launched by the Minister for Education and the Arts in August. A submission detailing the TMAG Re-Development Plan Stage 1 proposal for the re-furbishment of the Customs House was made to the Parliamentary Standing Committee on Public Works in November. Final negotiations regarding the lease are in progress between the State Government and the Commonwealth Government. Considerable consultation has taken place with regard to the design and planning of the new Royal Society Lecture Theatre and office facilities and lounge to be shared with the Friends.

The management of the West Coast Pioneer Memorial Museum has been handed over to a new company limited

by guarantee known as West Coast Heritage Pty Ltd. The *WCPMM Act* 1965 has been repealed and the Trustees have agreed to lend the collection to West Coast Heritage for a period of ten years with an option to renew. The members of the Local Advisory Board of the WCPMM have become the directors of West Coast Heritage, employing their own staff with some funding assistance from the State Government.

The Tasmanian Museum and Art Gallery has, in the pursuit of its stated goals, provided a varied exhibition program and instituted changes within its structure to emphasise and facilitate public access to its collections.

Major exhibitions generated by the TMAG include *Antarctica — Secrets of the Frozen World* (a partnership with the Museum of Victoria) 91,000 visitors; *The Exhibition Exhibition* — a celebration of the 1894 International Exhibition in Hobart; *Collectors and Benefactors — The Hood and Easterbrook collections of ceramics.*

Major travelling exhibitions included *Arthur Boyd Retrospective* from the Art Gallery of NSW, 9700 visitors.

Annual visitor numbers to the TMAG for 1994 were 138 661, a substantial increase over the previous year.

Mr J.E. Tomlinson AO was elected by Council to serve on the Board of Trustees of the Royal Tasmanian Botanical Gardens. Mr Tomlinson reports on the year's activities:

The significant change was that it was the first full year of our Director, Dr David Bedford, who had commenced in October 1993. He quickly settled in and came to grips with the management of the gardens and progress is being made on many fronts.

For the year 1994–95 the government has increased the grant from $1.15 million to $1.4 million. This will enable a pick up of the backlog on maintenance, etc. which was becoming serious. They have also offered a further $50 000 on a dollar-for-dollar raised by the Royal Tasmanian Botanical Gardens by its own efforts. This should be realised.

Attendances for the year to June were 304 778 — 10 720 up on the previous year. The gardens are one of the top tourist attractions in Tasmania.

Strong winds in January destroyed five large trees but fortunately no one was injured.

Mr Mark Fountain joined the staff in June as Nursery Manager. Mrs Ann Schmidt who had been on the staff for well over twenty years and had managed the nursery pending Mark's appointment, retired in December.

In December the Director was able to visit Macquarie Island as part of a plan to establish an Alpine and Sub-Antarctic Plant House at the gardens.

In co-operation with the Department of Transport and Works, the Gardens have been active in rescuing 19 threatened species of plants as roads have been constructed. They have also been active in planting other threatened species in the Gardens to ensure their preservation.

Acknowledgements

The Council is grateful for help generously given by many individuals and organisations. In particular, the lecturers, the Government of Tasmania, the University of Tasmania, Arts Tasmania, the Tasmanian Museum and Art Gallery, and the Queen Victoria Museum and Art Gallery are specially thanked for their support and cooperation . We draw attention with thanks to financial help by North Forest Products in making possible a lecture by an interstate visitor.

Essential Oils of Tasmania Pty Ltd, the Royal Hobart Hospital and CSIRO Divisions of Oceanography and Fisheries hosted visits by members to facilities under their control. The Society thanks these bodies for their hospitality.

The Society thanks Mr R. Buttermore and Mr A. Koo for their services as Honorary Secretary and Honorary Treasurer respectively in 1994.

Ms Sue Waterworth provided help as Minute Secretary in the first half of the year and in 1993 for which the Society is grateful. The thanks of the Society are also due to Ms Vicki Farmery, administrative assistant for her considerable help in 1994.

M.R .Banks
Vice-President
1 February 1995

Roger Buttermore
Honorary Secretary

ROYAL SOCIETY OF TASMANIA

Balance Sheet as at 31 December 1994

1993			*1994*
67 009.96	Accumulated funds		79 260.58
277.00	Subscriptions in advance		
	Trust funds		
2356.49	• Clive Lord Memorial	2375.89	
5005.38	• A.N. Lewis Memorial	5032.84	
2377.17	• Morton Allport Memorial	2404.25	
909.45	• A.A. Clark Bequest	909.45	
2538.51	• Joseph Milligan Bequest	2538.51	
3385.67	• R.M. Johnston Memorial	3416.80	
1395.41	• Henry Oliver Bequest	1395.41	
3260.16	• W.H. Hudspeth Memorial	3260.16	
6916.68	• Life Membership Fund	7004.77	28 338.08
$95 431.88			$107 598.66
	Represented by:		
33.00	Cash on hand		
	Cash at bank		
28 393.46	• General account	40 458.29	
4993.50	• Papers and Proceedings acct	5081.59	
1099.39	• Clive Lord Memorial	1118.79	
1555.53	• A.N. Lewis Memorial	1582.99	48 241.66
860.00	Mortgage Loan		860.00
7000.00	Interest bearing deposits		7000.00
15 000.00	Library (at valuation for insurance)		15 000.00
30 897.00	Publications (at estimated net realisable value)		30 897.00
5600.00	Medals (at selling price)		5600.00
$95 431.88			$107 598.66

Accumulation Account

	Balance at 1 January 1994		67 009.96
Add	Increase cash at bank		12 064.83
	Decrease in Advance Subs		277.00
			79 351.79
Less	Transfer to Trust Fund	58.21	
	Decrease in cash	33.00	91.21
			$79 260.58

Statement of Receipts and Payments Year ending 31 December 1994

Balance - 1 January 1994			$28 393.46
Add Receipts			
Subscriptions			
250 @ ¢35	8750.00		
117 @ $20	2340.00		
22@ $15	330.00		
Other years	896.00	12 316.00	
Publications		3443.95	
Interest		997.65	
Interest - Allport & Johnston		58.21	
Grants		11 000.00	
Excursion		240.00	
Donations		130.00	
Room hire		314.40	
Christmas dinner function		2550.00	31 050.21
			$59 443.67
Deduct payments			
Library and subscriptions		1958.25	
Print and stationery		1257.47	
Postage		1847.85	
Attendants fees		1045.00	
Bank charges		61.25	
Papers and Proceedings		7184.35	
Post box		190.00	
Telephone		104.60	
Coach excursion		300.00	
Insurance		508.83	
Meetings		413.38	
Administrative expenses		1979.40	
Computer repairs		520.00	
Northern Branch subsidy		1500.00	
Sundries		115.00	18 985.38
Balance - 31 December 1994			$40 458.29

Royal Society of Tasmania (Northern Branch)

Statement of Receipts and Expenditure for the Year ending 31 December 1994

Receipts		*Expenditure*	
Subscriptions	165.00	Subscriptions to Hobart	110.00
Suppers	5.30	Printing and stationery	86.95
Sale of book	5.00	Postage	1001.35
Grant	1500.00	Post box	39.00
Bank interst	1.61	Secretarial	1152.25
Miscellaneous (o/draw cover)	430.00	Bank charges	15.05
	2106.91	Suppers	196.00
Balance at Trust Bank 1.1.94	515.87		2600.60
	2622.78		
Less sub. banked after 31.12.94	20.00	Balance 31.12.94	2.18
	$2602.78		$2602.78

Reconciliation Statement 1994

Credit balance as per Bank Statement 31.12.94		$2.18
Credit balance at 1.1.94	515.87	
Receipts for year	2106.91	
	2622.78	
Expenditure for year	2600.60	
	22.18	
Less cheque banked after 31.12.94	20.00	
Debit balance		$2.18

Independent Audit Report to Members of the Royal Society of Tasmania

Scope

I have audited the attached special purpose financial report comprising the Balance Sheet, Accumulation Account and Statement of Cash Receipts and Payments for the General Account of the Society for the year ended 31 December 1994. The Society's Committee of Management is reponsible for the preparation and presentation of the financial report and the information contained therein. I have conducted an independent audit of the financial report in order to express an opinion to the members of the Society on its prepration and presentation.

The financial report has been prepared for distribution to members for the purpose of fulfilling the Committee of Managment's financial reporting requirements under the Sopciety's constitution. I disclaim any assumption of reponsibility for any reliance on this report or on the financial report to which it relates to any person other than the members, or for any purpose other than that for which the report was prepared.

My audit has been conducted in accordance with the Australian Auditing Standards. My procedures included examination, on a test basis, of evidence supporting the amounts and other disclosures in the financial report. These procedures have been undetaken to form an opinion as to whether, in all material respects, the financial report is presented fairly.

The audit opinion expressed in this report has been formed on the above basis.

Qualification

As is common for organisations of this type, it is not practicable for the Society to maintain an effective system of internal control over donations, subscriptions and other fund raising activities until their initial entry in the accounting records. Accordingly, my audit in relation to fund raising was limited to amounts recorded.

Qualified Audit Opinion

In my opinion, subject to the effects of such adjustments, if any, as might have been determined to be necessary had the limitation referred to in the qualification paragraph not existed, the attached financial report presents fairly, the receipts and payments for the General Account of the Society for the year ended 31 December 1994 and its state of affairs as at that date.

T.O. Bayley
Chartered Accountant 7 March 1995

ASTACOPSIS GOULDI CLARK IN STREAMS OF THE GOG RANGE, NORTHERN TASMANIA: THE EFFECTS OF CATCHMENT DISTURBANCE

by Ivor O. Growns

(with one table and two text-figures)

GROWNS, I.O., 1995 (30:vi): *Astacopsis gouldi* Clark in streams of the Gog Range, northern Tasmania: the effects of catchment disturbance. *Pap. Proc. R. Soc. Tasm.* 129: 1–6. ISSN 0080–4703. AWT EnSight, 51 Hermitage Road, West Ryde, NSW, Australia 2114.

Populations of the giant freshwater crayfish, *Astacopsis gouldi*, were sampled in the Gog Range, northern Tasmania. Ten sites were sampled in relatively undisturbed and minimally disturbed areas, and in areas with a history of severe catchment disturbance. Larger numbers of *A. gouldi* were caught in two streams with relatively undisturbed catchments than in three streams in heavily disturbed catchments. Thus, the abundance of *A. gouldi* in the Gog Range appears to have been adversely affected as a result of the disturbance of the original vegetation. Although the precise mechanism of the impact cannot be determined from this study, sedimentation and the presence of culverts may be preventing recolonisation of the disturbed streams. This study indicates the potential for catchment disturbance to affect populations of *A. gouldi* and highlights the need for proper management of land uses that may be detrimental to this species.
Key Words: ***Astacopsis*, catchment disturbance, Tasmania**

INTRODUCTION

The giant freshwater crayfish, *Astacopsis gouldi* Clark 1936, is the world's largest freshwater crayfish and is endemic to northern parts of Tasmania. It is widely distributed in streams, rivers and reservoirs draining to Bass Strait, as well as in the Arthur River system in far northwestern Tasmania (Swain *et al.* 1982).

The status of *A. gouldi* has been described as "vulnerable" by the International Union for the Conservation of Nature in its *Invertebrate Red Data Book* (Wells *et al.* 1983), "indeterminately threatened" by Horwitz (1990) and "threatened" by Horwitz (1994). The main processes that have been identified as having the potential to disrupt populations of this species include fishing pressure and destruction of habitat e.g. through land clearing (Lynch 1969, Horwitz & Hamr 1988, Hamr 1990).

There is little information about the habitat requirements of *A. gouldi* and how changes in land use affect populations. Changing the land use in a formerly pristine catchment, such as clearing land for agricultural or forestry purposes or the removal of riparian vegetation, is likely to severely disrupt crayfish habitat. This could happen in several ways. Increased light and temperature levels, modification of habitat structure and a decrease or change in the input of woody material can all result from the removal of riparian vegetation (Graynoth 1979, Haefner & Wallace 1981, Silsbee & Larson 1983, Campbell & Doeg 1989). These factors can reduce water quality and the number of refuges and amount of food available to the crayfish. Conversion of native riparian vegetation to alien species, such as willows and pines, may also reduce available food or refuges. An intact riparian vegetation strip left along the stream edge can ameliorate not only these effects but those of other anthropogenic disturbances, such as increases in sedimentation and pesticides, by acting as a buffer between the land use and the stream system. Intact riparian vegetation also maintains stream integrity and morphology (Erman *et al.* 1977, Newbold *et al.* 1980, Culp & Davies 1983).

The aim of this study was to assess the impacts of alteration of catchment vegetation on *A. gouldi* populations in the Gog Range, northern Tasmania. This was achieved by comparing the abundance and population structure in streams running through catchments with different histories of catchment disturbance, including old *Pinus radiata* plantations (with regeneration of native riparian components), recently cleared land (with an intact riparian zone), and relatively undisturbed catchments with native vegetation. Some of the sites were subject to fishing pressure, as indicated by the presence of bait lines.

STUDY SITES

A total of ten sampling sites was established on Garden of Eden Creek, Eel Hole Creek and tributaries of the Minnow River draining the northern face of the Gog Range in northern Tasmania (fig. 1, table 1). The streams are second or third order, approximately 1 m wide, within 8 km of each other and geomorphologically homogeneous.

The catchments of Garden of Eden and Eel Hole Creeks are dominated by natural vegetation. There is a small portion near the headwaters of Garden of Eden Creek which now supports young pine (*Pinus radiata*) plantations, and some agricultural land near where Garden of Eden Creek runs into the Mersey River. Also, a small section of Garden of Eden Creek catchment was clearfelled in the spring and summer of 1992.

The catchment of Garden of Eden Creek has a *Eucalyptus delegatensis* and *E. viminalis* canopy with an understorey of *Olearia argophylla, Acacia melanoxylon, Coprosma quadrifida* and *Dicksonia antarctica.* The dominant ground-cover plants are *Pteridium esculentum* (bracken fern), *Rubus fruticosus* (blackberry), and *Blechnum nudum.* The substratum of the sampling sites in Garden of Eden Creek appeared to be slightly silted, possibly due to the clearfelling within its headwaters.

Eel Hole Creek catchment is dominated by rainforest species including *Nothofagus cunninghamii, Atherosperma moschatum, Acacia melanoxylon* and *Pomaderris apetala.* The understorey comprises *Olearia argophylla, Coprosma quadrifida, Dicksonia antarctica* and *Gahnia grandis.*

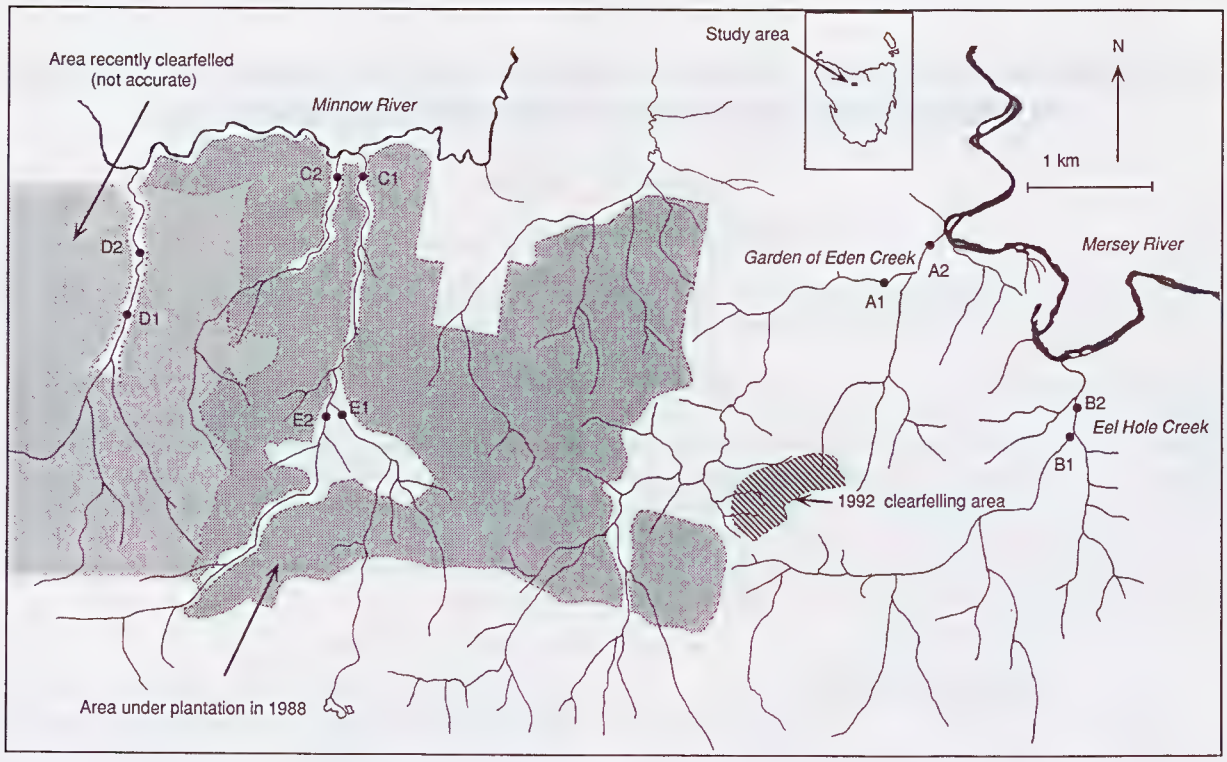

FIG. 1 — Site locations within the Gog Range.

TABLE 1
Characteristics of sampling sites

Site	Altitude (m)	Canopy cover (%)	Width of riparian zone present during land clearing within catchment	Catchment history
A1	100	50	None in headwaters	Headwaters cleared, selectively logged forty years ago
A2	100	5	None in headwaters or in agricultural section	Headwaters cleared, selectively logged forty years ago and area nearby converted to pasture
B1	120	70	-	Natural vegetation
B2	100	70	-	Natural vegetation
C1	200	<15	40 m wide*	Clearfelled, no regeneration
C2	200	35	40 m wide	Clearfelled, ten year old pine plantation
D1	220	20	40 m wide	Recently clearfelled, no regeneration
D2	240	20	40 m wide	Recently clearfelled, no regeneration
E1	250	35	0 m	Heavy selective logging 15-17 years ago, natural regeneration but old pine plantation nearby
E2	250	60	0 m	Heavy selective logging 15-17 years ago, natural regeneration but old pine plantation nearby

* But damage exists resulting from passage of a skidder through the stream in several places.

Two sampling sites were established on each of these streams, A1 and A2 (on Garden of Eden Creek) and B1 and B2 (on Eel Hole Creek). Sites A1, B1 and B2 were surrounded by natural vegetation, while site A2 was located within the agricultural land section. Pasture up to the waters edge allowed easy access to the water at this site.

The remaining six sampling sites (C1, C2, D1, D2, E1 and E2) were established on three tributaries of the Minnow River (fig. 1). The vegetation surrounding these sampling sites varied from natural regeneration after heavy selective logging (surrounded by old pine plantation), with no streamside reserve, to recently clearfelled with no regeneration but with a 40 m streamside reserve required under the Tasmanian Forest Practices Code (table 1). The dominant remaining native vegetation within the catchments of these streams is similar to that of Garden of Eden Creek, although the understorey in the heavy selectively logged area had a dense understorey of *Pomaderris apetala*. A native Blackwood (*Acacia melanoxylon*) plantation was planted within the catchment of site C1, but no regeneration had taken place by the time of the present study. Sedimentation at these sites (as indicated by casual observation) ranged from negligible at sites C2, E1 and E2, with some evident in D1 and D2, to heavy sedimentation of parts of C2.

The clearfelling that took place at sites E1 and E2, where no streamside reserve was left intact, was undertaken on private land. This land has since been purchased by the Forestry Commission.

METHODS

Sampling was carried out during the summer of 1993, from 9 January to 13 March. Each site was sampled nine times during this nine-week period. At each of the ten sites, 150 m of stream was marked with surveyors tape. Between 10 and 15 fresh mutton baits were laid along the same length of the stream each day. All baited lines were inspected periodically throughout the 6-8 hr sampling period each day. If a bait remained untouched for several hours, it was usually moved to a new location within the sampling area. In addition to baiting, crayfish were also collected by hand by overturning logs and rocks wherever possible. A team of two people usually sampled two sites on each day. Thus, the effort used to catch crayfish was the same, wherever possible, at each site over the entire sampling period.

Because of the likelihood of encountering more than one species of *Astacopsis* in the streams of the Gog Range, each animal caught was identified according to Hamr (1992). Animals were marked with an unique identifying tail puncture and a number scratched on the top of the carapace. The carapace length (cpl), the length from the rostrum tip to the back of the carapace, and the sex of every individual caught were recorded. Large females were examined for the presence of eggs or young. Animals with soft carapaces were also noted, as this is an indication of the animals having either just moulted or being about to.

As an indication of recreational fishing pressure at each site, the presence of bait lines was noted. The lines were then removed, so that new bait lines could be identified during the sampling period.

RESULTS

A total of 131 individual *A. gouldi* were caught, ranging from 10.0 to 177.8 mm cpl, in approximately 630 fishing hours (fig. 2). Five *A. tricornis* were also collected from sites B1, B2, E1 and E2, ranging from 27.0 to 47.2 mm cpl.

The greatest number of crayfish were caught at sites B1 and B2 (40 and 42 individuals respectively) in the undisturbed catchment on Eel Hole Creek (fig. 2). Approximately half as many crayfish were caught at sites A1 and A2 on the Garden of Eden Creek. A total of seven A. *gouldi* were caught at the six sites on the tributaries of the Minnow River, with highly disturbed catchments.

Of the 131 crayfish caught, only 11 were of legal size (i.e. > 130 mm carapace length). Most animals caught were less than 80 mm cpl, and these were caught at sites A1, A2, B1 and B2 (fig. 2). The size distribution of crayfish with carapace lengths greater than 80 mm is evenly spread at all sites. Most of the crayfish from the disturbed sites were large males (greater than 100 mm cpl). Of all the crayfish marked, only 16 (12%) were recaptured at least once.

Three female crayfish carrying young were caught, two individuals at site A1 (137.0 and 129.0 mm cpl) and one individual at site B2 (122.7 mm cpl).

Three crayfish were observed moving between sites on Eel Hole Creek (sites B1 and B2). Two males (101.0 and 87.5 mm cpl) were caught and marked at site B1 and subsequently recovered from site B2. A berried female (122.7 mm cpl), originally marked at site B2, was recaptured at site B1. This indicates that individuals of this species are motile and that marked animals are capable of moving out of the study areas.

Bait lines were observed at all sites except C1 and C2. The only site with old and new bait lines was A2, possibly indicating ongoing fishing pressure at this site.

DISCUSSION

This study has shown that *A. gouldi* populations are virtually non-existent in streams of catchments that have been heavily disturbed by clearfelling within the Gog Range. Also, the catches of this species at sites in the undisturbed catchment (Eel Hole Creek) were double that in the stream with the majority of its catchment covered by native vegetation but with some catchment disturbance (Garden of Eden Creek). These results are supported by other literature, which indicates that habitat degradation or destruction can be detrimental to populations of freshwater crayfish in Australia and the Northern Hemisphere (Westman 1985, Geddes 1991, Merrick 1993, Horwitz 1994).

This study to establish the effects of catchment disturbance on populations of *A. gouldi* could be criticised on the grounds that there is no information available on the abundances of this species before the disturbance took place; the streams may have supported different densities of *A. gouldi* before European settlement. There is no obvious reason why the populations within each of the streams should have been different before then. All the streams are of a similar altitude, width and geological type, and would have similar rainfall and discharge patterns. However, the possibility cannot be ruled out that there may have been other factors, not measured in this study, that were different between the streams and could have affected the abundances of *A. gouldi*.

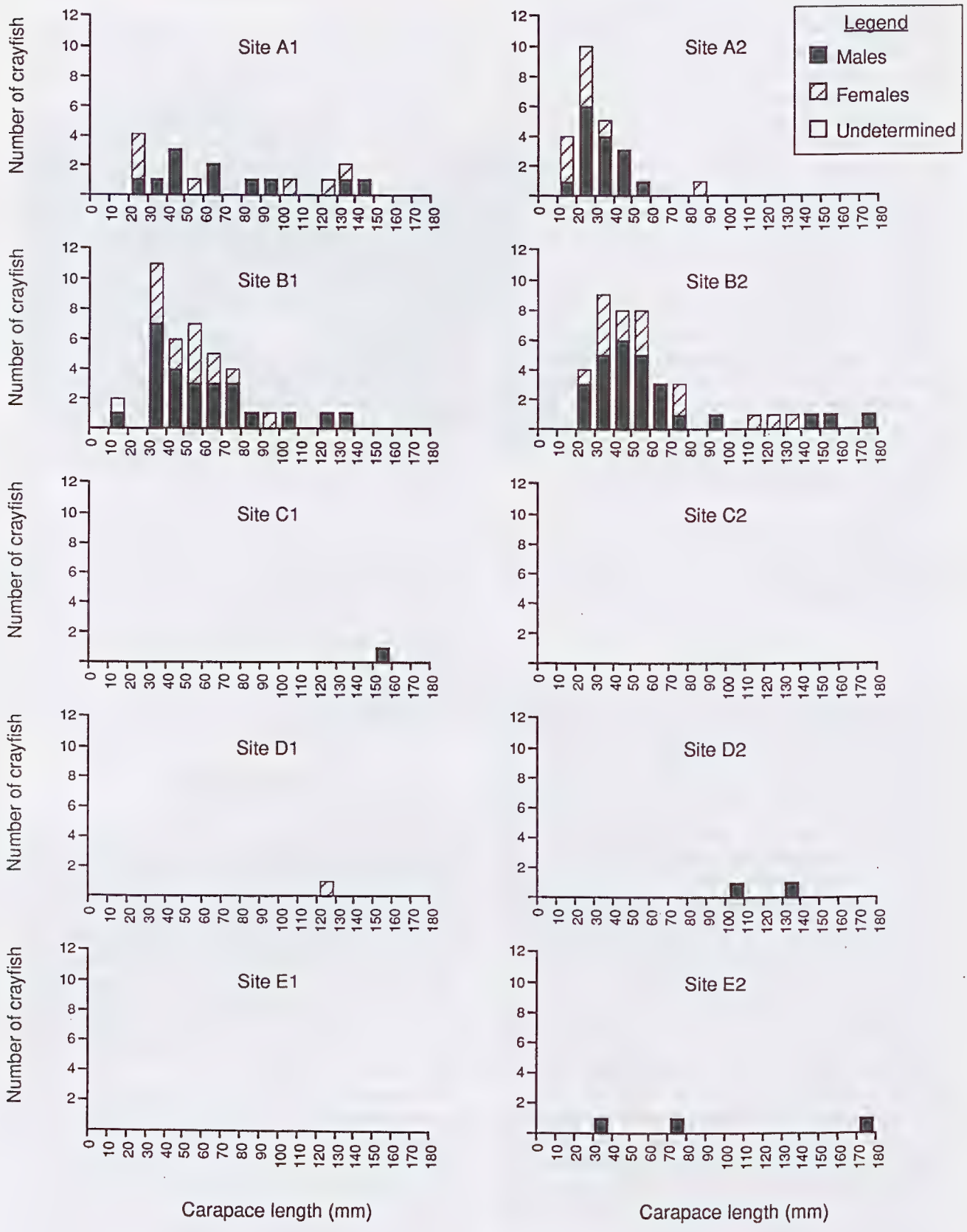

FIG. 2 — Length frequency distributions of crayfish caught at each site.

A much larger population of *A. gouldi* was expected in the streams in the heavily disturbed catchments, because the stream morphology at most sites appeared similar to that of streams with mostly intact native vegetation. One would have expected, therefore, recolonisation of these habitats after any initial adverse effects of clearfelling. There are several reasons why recolonisation may not have taken place within these streams.

Firstly, the present habitat in the tributaries of the Minnow River used in this study may be unsuitable for recolonisation. It is unlikely that the present habitats are totally unsuitable for crayfish, because some large crayfish and small *Astacopsis* already exist there and, as noted earlier, all the streams generally resemble each other. However, the amount of sediment observed at some sites may be limiting habitat availability in some manner.

Secondly, individual crayfish may be relatively sessile, have small home ranges and not readily migrate to new areas. It is unknown how motile *A. gouldi* individuals are, but crayfish in the present study were recorded moving between sites on the same stream. Also, only a small percentage of animals that were marked over 100 m of stream at each site were recaptured, indicating that they may have moved outside the study areas. These findings suggest that this species is relatively motile and, therefore, it is likely that disturbed areas would be recolonised, if opportunities arose to do so.

Thirdly, there may be no nearby breeding populations to provide recruitment. A large proportion of the catchment of the Minnow River has been cleared for agricultural purposes, and crayfish populations are subject to strong fishing pressure (J. Dudley & J. Nelson, pers. comm.). Habitat degradation and fishing pressure within the rest of the Minnow River catchment may limit the numbers of animals that are able to recolonise areas denuded of crayfish. However, the Minnow River is known locally as a good "lobster" creek (J. Nelson, pers. comm), indicating that it may support a substantial population of crayfish.

Finally, recolonisation may be prevented, due to limited available crayfish passage from recruiting areas. Each of the sites that were sampled on the tributaries of the Minnow River are separated from the Minnow River by between one and four culverts (round pipes laid under roads to allow passage of water). There is increasing evidence that crayfish are not able to negotiate passage through culverts, because of the higher velocity of water that travels through them and the smooth sides that do not allow the crayfish to obtain a grip (Horwitz 1991). However, there is anecdotal evidence which suggests that crayfish can move over land to reach streams. This behaviour is common in the mainland crayfish genus *Euastacus* (Morgan 1983), but it is not known how common it is in *A. gouldi.*

The influence of fishing pressure on *A. gouldi* populations in the Gog range cannot be judged from the data produced during this study. Sampling of contrasting populations with and without fishing pressure was only available at sites with highly disturbed catchments and low numbers of crayfish; the small number of animals at these sites would limit the detection of differences between these populations. The sites with relatively undisturbed catchments all had some indication of fishing pressure. However, without knowing the extent of the fishing pressure and the number or size of animals removed by recreational fishers at these sites, it is difficult to determine any effect of fishing.

This study has been a small-scale survey on various factors affecting populations of *A. gouldi,* and the conclusions that can be drawn from it are limited by the nature of the sampling design and the lack of the general knowledge of the biology, ecology and behaviour of *A. gouldi.* To identify the mechanisms of how changes in land use affect crayfish populations, and other issues, such as barriers to recolonisation, further research is needed, so that effective management can be put in place. This study indicates the potential for land clearing to affect populations of *A. gouldi* and highlights the need for proper management of land uses that maybe detrimental to this species.

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(accepted 15 June 1994)

THE ROTIFERS OF HEARD ISLAND: PRELIMINARY SURVEY, WITH NOTES ON OTHER FRESHWATER GROUPS

by Herbert Dartnall

(with two tables and seven text-figures)

DARTNALL, H. J. G., 1995 (30:vi): The rotifers of Heard Island: Preliminary survey, with notes on other freshwater groups. *Pap. Proc. R. Soc. Tasm.* 129: 7–15. ISSN 0080-4703. Copper Beeches, 76 Lewes Road, Ditchling, Sussex BN6 8TY, UK; formerly Australian Antarctic Division, Kingston, Tasmania.

Twenty rotifers (three Bdelloidea and 17 Monogononta, including new species of *Encentrum* and *Notholca*), a platyhelminth, gastrotrich, two nematodes, two tardigrades, one enchytraeid worm, four cladocerans, two copepods and three species of mites were recovered from five small pools on Heard Island. The results indicate that the Heard Island fauna is closer to that of Signy Island and Macquarie Island than to that of the much nearer Kerguelen archipelago.

Key Words: rotifers, Heard Island, zoogeography, sub-Antarctic islands.

INTRODUCTION

Heard Island (52°58'–53°12'S: 73°15'–73°51'E) is a small "turtle-shaped" island situated in the southern Indian Ocean, approximately halfway between South Africa (4850 km to the west) and Australia (4350 km to the east), and 1650 km north of the Antarctic Continent (fig. 1). The main body of the island consists of a mountain, Big Ben, topped by a volcanic peak rising to 2745 m. Much of the island is heavily glaciated, the climate severe and, at sea-level, average temperatures only marginally above freezing. The island was first sighted 1833 and was subsequently exploited by sealers (Headland 1989).

A number of the early Antarctic expeditions visited the island, and from 1948 until 1955, a small meteorological base was maintained there by the Australian National Antarctic Research Expeditions (ANARE). Since then, several private expeditions, as well as periodic visits by members of ANARE, have taken place (Headland 1989). On one of the latest of these (January 1991), five freshwater pools were sampled, and the results obtained are presented here.

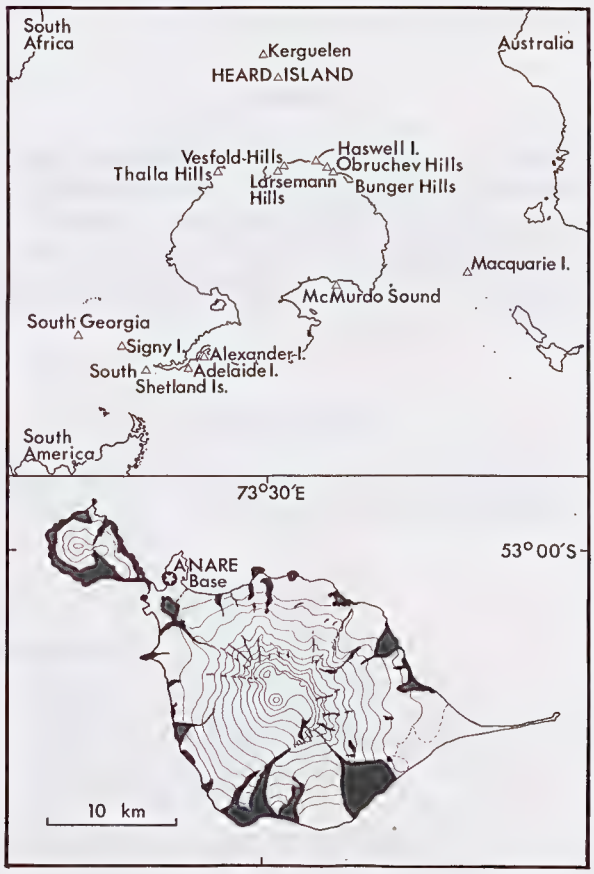

FIG. 1 — Upper: map showing Heard Island and all the other Antarctic and sub-Antarctic locations mentioned in the text. Lower: map of Heard Island showing the position of the old ANARE base; the black areas are exposed rock; the thin lines mark the 200 m ice contours and the broken line the limit of the ice field.

MATERIALS AND METHODS

Collection and Examination Procedures

In very shallow pools, the plastic collecting bottles (1 litre) were filled simply by immersing them. In deeper water (>0.3 m), the bottles were filled from a handnet (0.36 m cone made of 53 µm mesh), which was swirled through the water. In both cases, the samples were augmented with small scoops of benthic vegetation. All of the samples were collected on 31 January 1991 and were stored at 4°C prior to examination five days later at Davis Station, where they were filtered through a 20 µm mesh and then examined under a dissecting microscope.

Permanent slides were made using polyvinyl-lactophenol, following the method of Russell (1961). The pH (Corning pH meter model 240) and the conductivity (Microprocessor Conductivity Meter model LK196) of the filtrate was determined.

Study Sites

Five pools, located some 200–400 m to the east of the old ANARE meteorological base on Atlas Cove (fig. 1), were sampled. Here, there were numerous bodies of water amongst the cushion plants (*Azorella selago*) and tussock grass (*Poa cookii*). All were small and shallow, the largest one sampled being some 4 m × 6 m and just 0.5 m deep. Details of the size of each pool, its approximate distance from the old ANARE meteorological base and other pertinent information are given in table 1.

RESULTS

Identification of the Fauna

The collection, which was made as an adjunct to a survey of rotifers from the Australian Antarctic Territories, contained a number of other invertebrates. Since the freshwater fauna of Heard Island is very poorly known, brief notes on all species found are included. Their distribution in the five pools is given in table 2.

Protozoa

Protozoa were observed in all of the samples with benthic vegetation and mostly consisted of small spherical, and elongate, colourless ciliates. A few large paramecium-type ciliates were seen; testate amoebae (*Arcella* sp.) were observed amongsts algal filaments (*Spirogyra* sp., *Vaucheria* sp. and *Zygnema* sp.). Suctoria and vorticellids decorated the shells of many of the cladocerans.

Platyhelminthes

Several specimens of a large non-eyed acoel were seen in three of the pools (Nos 1, 4 and 5).

Gastrotricha

Only two specimens were seen in sample 4. Both were covered in fine sensory bristles (*Chaetonotus* sp.).

Tardigrada

Tardigrades were found amongst the benthic vegetation. Two species have subsequently been identified: a *Dactylobiotus* sp. and *Hypsibius* sp. (probably *H. antarcticus*).

Nematoda

Nematodes were found in all of the scoops of benthic vegetation. Two species were recognised but have not yet been identified.

Rotifera

Twenty species of rotifer were found — seventeen Monogononta and three Bdelloidea. Only *Habrotrocha* sp. was found in every sample. Eleven species were found at just one location.

Monogononta

Epiphanes senta (0. F. Muller) (fig. 2A)

This large (>600 µm) illoricate species was found only in sample 5, where it was fairly common. The corona bears several tufts of strong cilia. The mastax has malleate trophi, and each uncus bears five principal teeth and several minor ones (fig. 2A). Males were not seen. The specimens found are in close agreement with the published descriptions and measurements for this species (Koste 1978).

Epiphanes senta is cosmopolitan and is usually found in small pools enriched with excreta of domestic animals. In

TABLE 1
Details of the five pools sampled

Pool no.	Distance to east of ANARE base (m)	Size (m)	Depth (m)	Sampling method*	Pool environment
1	200	2 x 1	0.35	A, B	Surrounded by tussock grass and cushion plants
2	200	6 x 4	0.50	C	Surrounded by tussock grass and cushion plants
3	400	4 x 1	0.30	2 x A,C	–
4	400	3 x 1	0.30	2 x A,C	Pool rich with filamentous green algae
5	400	4 x 1	0.10	2 x A,B	Surrounded by cushion plants, bare earth/mud, frequented by elephant seals

* A = benthic scoop, B = immersion sample, C = plankton net.

TABLE 2
Distribution* of invertebrates in the five pools on Heard Island

Pool	No. 1	No. 2	No. 3	No. 4	No. 5
pH	7.01	6.52	6.05	6.48	6.53
Conductivity µS/cm	161	135	184	174	265
Protozoa	+	+	+	+	+
Plathyhelminthes	+	–	–	+	+
Gastrotricha					
Chaetonotus sp.	–	–	–	+	–
Tardigrada					
Dactylobiotus sp.	–	–	+	+	+
Hypsibius antarcticus?	+	–	+	+	–
Nematoda	+	–	+	+	+
Rotifera					
Cephalodella sterea	+	–	–	–	–
C. ventripes	–	–	–	+	–
Collotheca ornata cornuta	–	–	–	+	+
Colurella colurus compressa	–	–	–	+	–
Encentrum heardensis	+	–	–	–	+
E. mustela	+	–	–	+	+
Epiphanes senta	–	–	–	–	+
Euchlanis sp.	–	–	–	+	+
Lepadella patella	–	–	–	+	–
L. triptera	–	–	–	+	–
Lindia torulosa	+	–	–	+	–
Notholca hollowdayi	+	–	+	+	–
Notommata glyphura	–	–	–	+	–
Ptygura sp.	–	+	–	–	+
Resticula gelida	–	–	–	–	+
Rhinoglena frontalis	–	+	+	–	+
Trichocerca brachyura	–	–	+	+	–
Adineta sp.	–	–	–	+	–
Habrotrocha sp.	+	+	+	+	+
Rotatoria rotatoria	–	–	–	+	–
Annelida					
Enchytraid worm	+	–	+	+	+
Arthropoda					
"Chydorid" 2 spp.	–	+	+	+	+
Macrothrix sp.	–	+	+	–	–
Daphniopsis studeri	–	+	+	+	–
Pseudoboeckella remotissima	+	+	+	+	–
Harpacticoid†	–	–	–	+	–
Alophagus antarcticus	+	+	+	–	+
Halozetes marinus?	+	–	–	+	–
P.auberti occidentalis	+	–	–	–	–

* Key: + present, – not found
† According to Smith & Sayers (1971) the Heard Island harpacticoid is *Epactophanes richardi antarcticus* (Richters).

the Antarctic, it is found in pools enriched by penguins and seals. It has been reported from the McMurdo Sound area (Murray 1910, Armitage & House 1962, Dougherty & Harris 1963); from fresh and brackish pools in eastern Antarctica, in the Bunger Hills (Korotkevich 1958), at Haswell Island (Kutikova 1958, Donner 1972), and in the Larsemann Hills (Dartnall 1995); from the South Shetland Islands (de Paggi 1982) and the South Orkney Islands (Dartnall & Hollowday 1985); and from the sub-Antarctic Macquarie Island (Dartnall 1993)

Rhinoglena frontalis Ehrenberg (fig. 2B, C)

This was the commonest species in sample 2. A few specimens were also seen in samples 3 and 5. It is a large (>400 µm), slow-swimming species with two tiny toes. The corona is elongated dorsally into a rostrum that bears two prominent eye-spots. The mastax has malleate trophi and each uncus has seven teeth. This is a viviparous species and many specimens were carrying a single developing young. The specimens found are in close agreement with the published descriptions

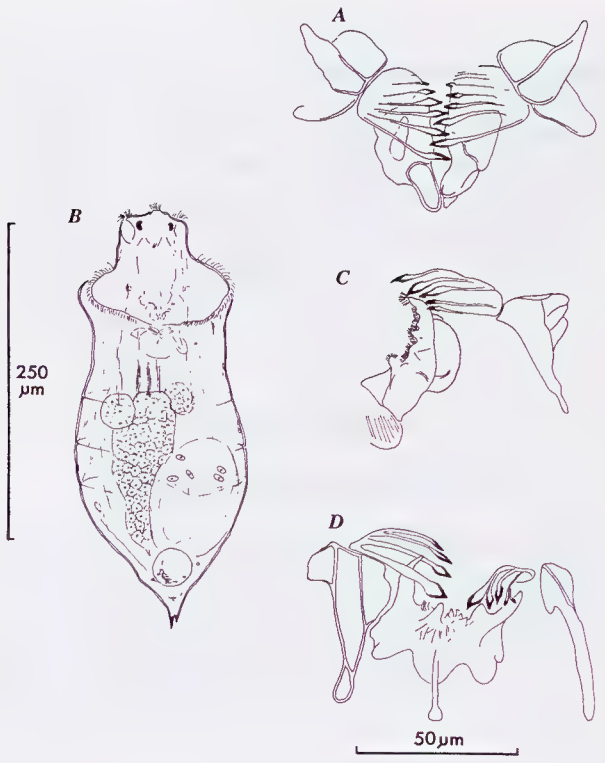

FIG. 2 — (A) Epiphanes senta: *trophus. (B, C)* Rhinoglena frontalis: *(B) frontal view of whole animal; (C) trophus only left half shown. (D)* Euchlanis *sp.: trophus — note that the left manubrium has been twisted through 90°.*

and measurements for this species (Koste 1978). Resting eggs and males were not seen.

Rhinolena frontalis is a cold stenotherm inhabiting shallow water. In the Southern Hemisphere, it has been reported from the Australian mainland by Shiel & Koste (1979), from Tasmania (Koste *et al.* 1988), from New Zealand (Russell 1960) and from Macquarie Island (Dartnall 1993). The closely related *R. fertoensis* Ehrenberg has been reported from the Antarctic in the Bunger Hills (Korotkevich 1958, Kutikova 1958).

Euchlanis sp. (fig. 2D)

Just two specimens of this rotifer were found — one in each of samples 4 and 5. The larger specimen had a dorsal plate 215 µm long and long, slender toes of 83 µm. A single, red eye-spot is present and the mastax has malleate trophi (fig. 2D). Males and resting eggs were not seen. These specimens are very probably *E. dilatata parva* Rousselet, but confirmation of this will have to await the examination of more specimens.

Euchlanis dilatata parva has been reported previously from the Antarctic and Subantarctic at Signy Island and South Georgia (Dartnall & Hollowday 1985). The Signy specimens exhibited a considerable range in size (from 240 to nearly 500 µm) while those from South Georgia were considerably smaller. Both specimens satisfy the original description by Rousselet (1892), who separated *E. dilatata* from *E. parva* on the basis of its small size, greater length and slenderness of the toes, and conspicuous lateral antennae. Considerable confusion exists in the literature over the differentiation into two species; indeed, Koste (1978), while retaining them as separate species, remarks that *E. parva* resembles a small form of *E. dilatata.* The situation is further confused given the fact that *E. dilatata* grows considerably in its first 24 hours of life (Liebers 1937). Dartnall & Hollowday (1985) considered them one and the same species.

Notholca hollowdayi sp. nov. (fig. 3A–D)

This new species was found in three of the five pools (table 2). It is a medium-sized rotifer more than 210 m long. The stiff dorsal lorica (200 µm) is oval and more than twice as long as it is wide (92 µm), the greatest width being just posterior of the midpoint. It is decorated with broad striations and series of small pits in the posterior region (Fig 3C). The median and lateral spines are long and are of similar length (22–25 µm). The ventral plate is somewhat smaller (165 µm), flat and undecorated. The anterior margin bears the median notch present in all members of this genera. There is a single, red eye-spot. The mastax has malleate trophi used for eating diatoms and their frustules were seen in a number of stomachs. The unci have three main teeth and up to two vestigial ones.

Notholca hollowdayi belongs to the walterkostei group but lacks the posterior tab of that species (de Paggi 1982, Dartnall & Hollowday 1985). A new/different species of *Notholca* has been described from almost every Antarctic/sub-Antarctic location sampled, which poses some interesting speciation and biogeographical questions. This is an area for further study.

Holotype

A microslide of a loricate female has been deposited at the Natural History Museum, London — museum registration number 1993.5119. *N. hollowdayi* is named after my colleague and rotifer mentor Eric D. Hollowday.

Colurella colurus compressa Lucks (fig. 4A)

This subspecies was only found in sample 4, where it was fairly common. It is a small species with lorica length c. 100 µm. All of the specimens exhibited the lateral compression characteristic of the subspecies *compressa.* The foot has three segments and two recurved toes which were longer than the foot segments. Overall, the measurements are in close agreement with the published descriptions and measurements for this species (Koste 1978).

Many authors have not differentiated *C. c. compressa* from the *sensu-stricto C. colurus,* so that it is difficult to determine their distribution. Both have been reported from the Antarctic before (for review, see Dartnall & Hollowday 1985) and, more recently, Dartnall (1993) reported *C. c. compressa* from Macquarie Island.

Lepadella patella (Müller) (fig. 4B)

This small species was found only in sample 4. It has an overall length of 140 µm and breadth of 65 µm. The small number of specimens found agrees closely with the published descriptions (Koste 1978).

Lepadella patella is cosmopolitan and has been reported

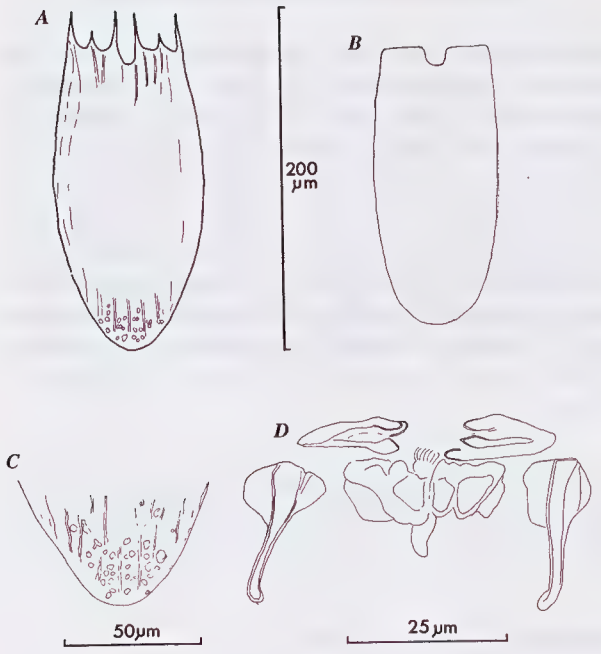

FIG. 3 — Notholca hollowdayi: *(A) lorica — dorsal plate; (B) ventral plate of lorica; (C) detail dorsal lorica; (D) trophus.*

from both Macquarie Island and Iles Kerguelen by Russell (1959). Other locations in the Antarctic include the Obruchev and Bunger Hills (Kutikova 1958, Korotkevich 1958), the Thalla Hills (Opalinski 1972), Langhovde (Sudzuki 1964), the Vestfold Hills (Everitt 1981) and the Larsemann Hills (Dartnall 1995).

Lepadella triptera Ehrenberg (fig. 4C)

This small species was found only in sample 4, where it was rare. The single specimen measured had a lorica length of 75 µm, width 46 µm and toes 21 µm long, all of which are in the accepted range for this species (Koste 1978).

Lepadella triptera is cosmopolitan and has been reported from the Antarctic at Signy Island (Dartnall & Hollowday 1985) and from the sub-Antarctic at Macquarie Island (Dartnall 1993)

Lindia torulosa Dujardin (Fig. 5A)

This large rotifer (>500 µm) was found in two of the pools, where it was fairly common. It is a flexible rotifer with two small toes and a very large, red eye-spot on the brain. The specimens were only observed crawling over the bottom, so that the auricles which appear when the animal swims were not observed.

Lindia torulosa is cosmopolitan and has been reported from one sub-Antarctic and four Antarctic locations. On the Antarctic Peninsula, Beauchamp (1913) recorded it at Jenny Island, while Heywood (1977) reported a new form, *L. torulosa antarctica*, from the nearby Alexander Island. Since then, it has been found in the Larsemann Hills (Dartnall 1995) and from Macquarie Island (Dartnall 1993). Interestingly, it has not been found at Signy Island.

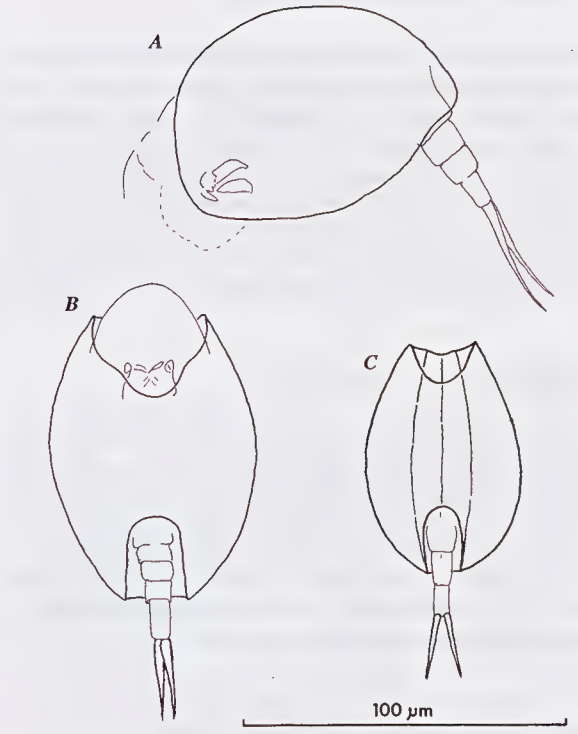

FIG. 4 — *(A)* Colurella colurus compressa: *lateral view of lorica and foot. (B)* Lepadella patella: *ventral view of lorica and foot. (C)* Lepadella triptera: *ventral view of lorica and foot.*

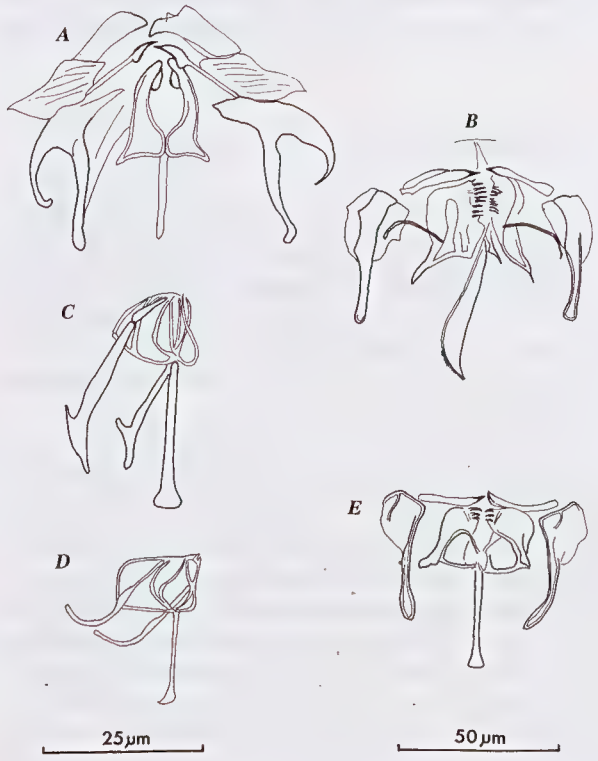

FIG. 5 — *(A)* Lindia torulosa: *trophus. (B)* Notommata glyphura: *trophus. (C)* Cephalodella sterea: *trophus. (D)* Cephalodella ventripes: *trophus. (E)* Resticula gelida: *trophus.*

Notommata glyphura Wulfert (fig. 5B)

This large species (>400 µm) was found only in sample 4. The species was yellow in colour with a brown tinge and had a large, conspicuous, red eye-spot. The virgate trophi are relatively large: 65 µm deep and 75 µm across — fulcrum 38 µm, rami 28–30 µm, manubria 38 µm and unci 24 µm.

Notommata glyphura has been reported from Europe (Koste 1978), Saudi Arabia (Segers & Dumont 1993), Senegal (de Ridder 1986), Australia (Koste & Shiel 1980) and Macquarie Island (Dartnall 1993).

Cephalodella sterea (Gosse) (fig. 5C)

Just one specimen of this small cephalodellid was found in sample 1. This specimen had an overall length of 168 µm. The body, including the foot, was 136 µm long and the toes were 31 µm long. The mastax has virgate trophi; the fulcrum is 21 µm long, rami 10 µm and manubrium 21 µm.

Cephalodella sterea has been reported from the Antarctic before — in the Obruchev Hills (Korotkevich 1958) and in the Larsemann Hills (Dartnall 1995).

Cephalodella ventripes Dixon-Nuttall (fig. 5D)

Two specimens of this small *Cephalodella* were found. The larger specimen had an overall length of 129 µm, with a body length, including the foot, of 98 µm and toes of 31 µm. This is a new record for the sub-Antarctic and has now also been found in the Larsemann Hills (Dartnall 1995).

Cephalodella ventripes has been recorded from New Zealand (Hilgendorf 1902) and Tasmania (Koste & Shiel 1987).

Resticula gelida (Harring & Myers) (fig. 5E)

Another large, soft-bodied rotifer; the specimens found in sample 5 were up to 400 µm long and are in close agreement with the published drawings and descriptions (Koste 1978).

Resticula gelida has a worldwide distribution and has been reported from the Antarctic at Adelaide Island (Dartnall 1980), from brackish pools at Signy Island (Dartnall & Hollowday 1985), and from the Larsemann Hills (Dartnall 1995).

Trichocerca brachyura (Gosse) (fig. 6A, B)

This small, kidney-shaped rotifer was found in samples 3 and 4. The right toe was much thinner than the left and approximately two-thirds in length (21 µm against 31 µm). The trophi of all the specimens measured (five) were 38 µm long and very asymmetrical. The left manubrium was crutch-shaped and 31 µm long; the right manubrium was much shorter and spindly. The specimens found agree very closely with the published descriptions and drawings (Koste 1978)

Trichocerca brachyura is cosmopolitan and has been reported from three Antarctic and sub-Antarctic locations; from South Georgia and Signy Island (Dartnall & Hollowday 1985) and from Macquarie Island (Dartnall 1993).

Encentrum heardensis sp. nov. (fig. 6C, D)

This new species was found in two pools (Nos 1 and 5). The body is illoricate and very flexible (up to 300 µm long) and bears two short, stubby toes (17.5 µm long). The mastax has forcipate trophi which are distinctive — 50 µm long and 25 µm wide. The manubria have swollen bases and are 33 µm long. The intramallei are small (c. 4.5 µm), and the unci powerful, curved (20 µm long) and pointed. The fulcrum is short (14 µm long) and spindly, while the rami are massive (20 µm long), with a deep body and a pointed edge to the inner median edge. No teeth were seen on the inner edge of the rami. *E. heardensis*, though distinct, bears some similarities to *E. mucronatum* Wulfert and *E. tobyhannaensis* Myers.

Holotype
A microslide of a female showing the trophus has been deposited at the Natural History Museum, London — museum registration number 1993.5118

Encentrum mustela (Milne) (fig. 6E)

This species was one of the commonest, occurring at three locations (table 2). The body is illoricate and very flexible. The mastax has forcipate trophi. The intramallei of most

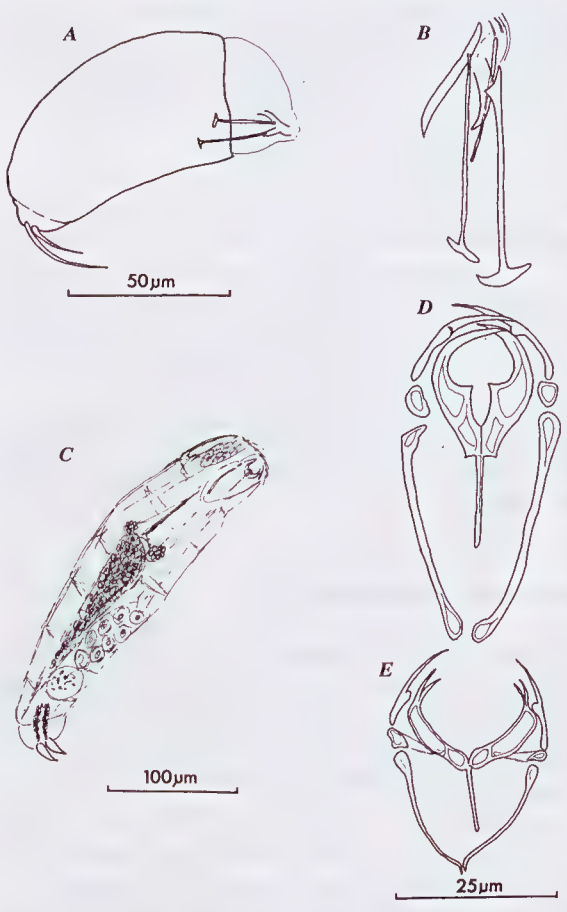

FIG. 6 — (A, B) Trichocerca brachyura: *(A) lateral view; (B) trophus. (C, D)* Encentrum heardensis: *(C) lateral view; (D) trophus. (E)* Encentrum mustela: *trophus.*

specimens have a delicate curved "tail" extending almost to the midline (fig. 6E). This structure, though present in many *Encentrum* species, has not been noted before in *E. mustela*. Previously the trophi were dissolved out in bleach — a practice that may have led to the loss of these delicate "tails"; it was not followed with the Heard Island specimens, where the whole animal was mounted in polyvinyl-lactophenol.

In Europe, *E. mustela* is regarded as a cold stenotherm. A solitary species, it probably has a circumpolar distribution. It has been reported from Signy Island (Dartnall & Hollowday 1985), from Macquarie Island (Dartnall 1993) and from the Larsemann Hills (Dartnall 1995).

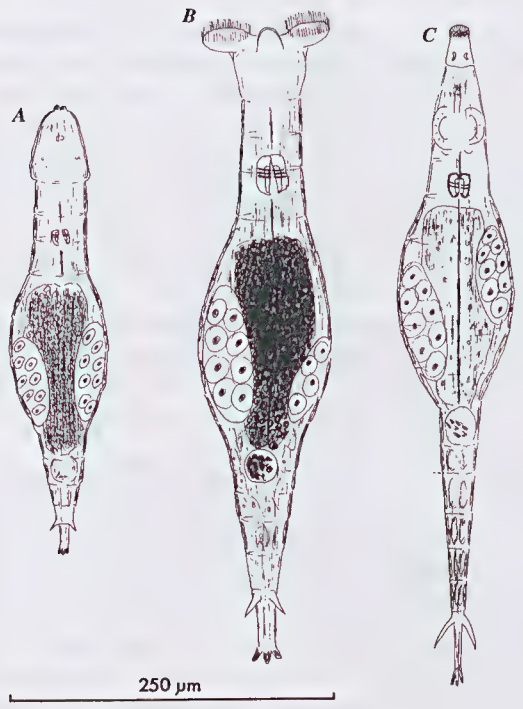

FIG. 7 — (A) Adineta *sp.: dorsal view. (B)* Habrotrocha *sp.: dorsal view. (C)* Rotaria rotatoria: *dorsal view.*

Ptygura sp.

A number of tube-dwelling rotifers were seen in sample 5. They are thought to be *P. crystallina* (Ehrenberg) but confirmation will have to wait examination of additional specimens.

Ptygura crystallina has a worldwide distribution and has been reported from the Antarctic and sub-Antarctic before. It has been found at Signy Island (Dartnall & Hollowday 1985), in the Vestfold Hills (identified as *Ptygura* sp. by Everitt [1981] but now confirmed as *P. crystallina*), in the Larsemann Hills (Dartnall 1995) and Macquarie Island (Dartnall 1993).

Collotheca ornata cornuta (Dobie)

This is one of the easiest rotifers to identify. The margin of the coronal funnel bears five knobs; the dorsal knob is longest, with a short, finger-like projection. A number of the larger specimens (>500 µm) had a single oval egg (45 × 30 µm) attached to the pedicel.

Collotheca ornata cornuta is cosmopolitan. It has been reported from the Antarctic region several times and undoubtedly has a circumpolar distribution. It was first recorded in 1910 by Murray, who found it at Cape Barne and Cape Royds (reported as *Floscularia cornuta* [Murray 1910]), and has subsequently been reported from there and nearby by Armitage & House (1962 — though their record is for *C. ornata*) and by Dougherty & Harris (1963). It has been reported from eastern Antarctica, from pools in the Obruchev Hills (Korotkevich 1958, Kutikova 1958), from the Larsemann Hills (Dartnall 1995), from Signy Island (Dartnall & Hollowday 1985) and from Macquarie Island (Dartnall 1993).

Bdelloidea

Adineta sp. (fig. 7A)

Just one specimen was seen in sample 4. This specimen was 350 µm long, transparent and appeared to be a juvenile. It bore no characteristic marks.

Habrotrocha sp. (fig. 7B)

This was the only rotifer found in every sample. The largest specimens were almost 600 µm long and yellow-grey in colour. The trochal discs are, when displayed, not much wider than the neck, and eye-spots are absent. The dental formula is 3/3. The dorsal antenna is short and the small conical spurs are joined at their bases. This would appear to be viviparous species — the largest specimen had five young developing within its body cavity.

Rotaria rotatoria Pallas (fig. 7C)

Another large bdelloid (>500 µm), this species was found only in sample 4. It has a smooth cuticle, a large prominent rostrum with two large, red eye-spots and a dental formula of 2/2.

Rotaria rotatoria is cosmopolitan and has been reported from Europe, North, Central and South America, central and South Africa, Australia and New Zealand (Bartos 1951). In the sub-Antarctic it has been recorded from South Georgia by Dartnall & Hollowday (1985 – they identified their single specimen as *Rotaria* sp., but it is now thought to be *R. rotatoria*), and from Macquarie Island (Dartnall 1993).

Annelida

A large enchytraeid worm was common amongst the samples of benthic vegetation. Similar worms have been found at Signy Island in the South Orkneys (Heywood, Dartnall & Priddle 1979), at Macquarie Island (Evans 1970), and at South Georgia.

Arthropoda

Four cladocerans, two copepods and three species of mite were seen. The largest of these is the cladoceran *Daphniopsis studeri* Rühe, which has been reported before from Heard Island (Smith & Sayers 1971), as well as from Kerguelen (Gay 1982) and in the Vestfold Hills (Korotkevich 1958) and Larsemann Hills (Dartnall 1995). The second largest cladoceran keys down to *Macrothrix hirsuticornis* Norman & Brady, a species which has been reported from a number of Antarctic and sub-Antarctic locations (at Signy Island [Heywood, Dartnall & Priddle 1979]; also at South Georgia [Dartnall & Heywood 1980], and at Macquarie Island [Evans 1970]). The late Prof. D.G. Frey (pers. comm.) has questioned the identification of "*hirsuticornis*" in the Southern Hemisphere, and the true identification of this species will have to await elucidation. The calanoid copepod is *Pseudoboeckella remotissima* Brehm. According to Smith & Sayers (1971), the harpacticoid at Heard Island is *Epactophanes richardi antarcticus* (Richters). Very few examples were found in the present survey and they have not yet been verified. Three species of mite, *Halozetes marinus*? Wallwork, *Podacarus auberti occidentalis* Wallwork and *Algophagus antarcticus* Hughes were found.

DISCUSSION

Although pool No. 4 contained the greatest number and variety of species (table 2), it is not thought to be significantly different from the other pools, when allowance is made for the different sampling methods employed (table 1) and the fact that some species are represented by just one or two specimens.

The wealth of data obtained was surprising, given the opportunistic nature of the sampling — all five pools were sampled within an hour. Similar samplings made at other antarctic locations have not been as successful. Thus, Beauchamp (1940) reported just two species of rotifer from Iles Kerguelen; Russell (1959) added a further ten, when he examined the samples obtained by Sir Douglas Mawson's British, Australian, New Zealand Antarctic Research Expedition of 1929–31, and Lair & Koste (1984) an additional two.

At South Georgia, Dartnall & Hollowday (1985) recorded 15 species from samples collected for them. They had made an extensive study at Signy Island and recorded 38 species, 11 of which were common to both locations (Dartnall & Hollowday 1985). They concluded that an in-depth study at South Georgia would not only find most of the "missing" 27 Signy species but additional temperate ones as well.

Such an expectation would appear to be supported by the most recent results from Macquarie Island. Here, Russell (1959) had originally identified only three species of rotifer from the creek running into Lusitania Bay, but a subsequent and more thorough examination of the major water bodies there identified 39 (Dartnall 1993)

As further evidence of the successful sampling at Heard Island, the collection picked up the larger micrometazoans that had previously been identified from there — i.e. the cladoceran *Daphniopsis studeri* and copepod *Pseudoboeckella remotissima* (Smith & Sayers 1971), the enchytraeid (Lee 1968) and the aquatic mite *Algophagus antarcticus* (Hughes 1955). Indeed, the overall composition of the fauna — an acoel, one species of gastrotrich, two nematodes, two tardigrades, 20 rotifers, one enchytraeid worm, and nine arthropods, made up of four cladocerans, two copepods and three mites — is very similar to the more detailed lists available for Signy and Macquarie Islands. The freshwater fauna list for Signy Island consists of an acoel, one species of gastrotrich, nematodes, tardigrades, 38 rotifers, an enchytraeid worm and 13 arthropods (an anostracan, three cladocerans, two ostracods, two copepods and five mites) (Heywood, Dartnall & Priddle 1979, Dartnall & Hollowday 1985, Pugh & Dartnall 1994). That for Macquarie Island consists of a platyhelminth, two gastrotrichs, nematodes, tardigrades, 39 rotifers, two enchytraeid worms, and 14 arthropods (an isopod, five cladocerans, two ostracods, two copepods and four mites) (Evans 1970, Dartnall 1993, Pugh & Dartnall 1994). The similarities extend to overall numbers for the various groups, even down to the level of genera.

Ostracods are notably absent from the Heard Island list. They are normally found in larger and deeper lakes than were sampled in this study. Rotifers, by virtue of their numbers, afford a more reliable basis for comparison of different locations. At Signy Island, there were 38 species of rotifer belonging to 20 genera (Dartnall & Hollowday 1985) and, at Macquarie Island, 39 species belong to 24 genera (Dartnall 1993), with 12 species and 16 genera common to both locations. At Iles Kerguelen, 14 species belonging to 12 genera have been reported (Beauchamp 1940, Russell 1959, Lair & Koste 1984). Kerguelen shares 11 genera and five species with Macquarie Island, and one species and nine genera with Signy Island. Heard Island, with 20 species belonging to 17 genera, shares 15 genera and 11 species with Macquarie Island, 13 genera and eight species with Signy Island, and only six genera and no species with Kerguelen.

All of this would seem to indicate that only about half the Heard Island rotifers have been found. At present, the fauna at Heard Island seems very dissimilar to its near neighbour Kerguelen and has much more in common with Macquarie Island, to the east, and South Georgia and Signy Island, to the west, but further studies are needed to clarify this.

ACKNOWLEDGEMENTS

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ROTIFERS, AND OTHER AQUATIC INVERTEBRATES, FROM THE LARSEMANN HILLS, ANTARCTICA

by Herbert J.G. Dartnall

(with two tables and two text-figures)

DARTNALL, H. J.G., 1995 (30:vi): Rotifers, and other aquatic invertebrates, from the Larsemann Hills, Antarctica. *Pap. Proc. R. Soc. Tasm.* 129: 17–23. ISSN 0080–4703. Copper Beeches, 76 Lewes Road, Ditchling, Sussex BN6 8TY, UK; formerly Australian Antarctic Division, Kingston, Tasmania.

Seventeen species of rotifer (11 Monogononta and six Bdelloidea), three tardigrades, two arthropods, as well as protozoans, a plathyhelminth and nematodes were found in 13 freshwater lakes in the Larsemann Hills.
Key Words: rotifers, lakes, zoogeography, Larsemann Hills, Antarctica.

INTRODUCTION

The Larsemann Hills (69°24'S, 76°20'E), situated on the Ingrid Christensen Coast of Princess Elizabeth Land, Antarctica, consist of a series of low-lying, rocky peninsulas and islands on the southern shore of Prydz Bay. This area (fig. 1), which extends over 200 km^2, is ice-free during the summer and bestrewn with more than 150 freshwater lakes. In the 1990/91 and 1991/92 austral summers, the opportunity arose to determine the rotifers of some of these lakes; the results obtained are presented here.

MATERIALS AND METHODS

Collection and Examination of Samples

Samples were collected in a number of ways. On the first visit, in November 1990, the lakes were all ice-covered so a 200 mm diameter hole was cut with a petrol-driven ice drill. Benthic samples were then obtained by means of a hand-operated baling pump, which was used to suck up the sediments and overlying water through rigid plastic tubing (after Dartnall & Hollowday 1985). Thereafter, this apparatus was deployed from the ice edge, or hung over the side of an inflatable rubber boat when sampling Lake Scandrett. Elsewhere, a fine (53 µm mesh) plankton net was allowed to sink, so that, when retrieved, it collected samples from or just above the bottom. Finally, fragments of cyano-bacterial mats were collected from around the shoreline. These mats, which had originated from deep water, were levitated to the surface by the production of gases and subsequently were blown to the lake edge.

The samples were examined at Law Base, using a binocular dissecting microscope and a high-powered compound microscope. Drawings were made from free-swimming specimens, from living specimens kept under slight compression by means of a coverslip mounted on vaseline, and from specimens relaxed and narcotised with tetra-sodium pyrophosphate (Robotti & Lovisolo 1972). Slides of trophi were made using polyvinyl-lactophenol (PVL), after the method of Russell (1961). A drop of PVL was put on the specimen and gentle pressure was applied to the coverslip to extrude the trophi. This method is less destructive than the usual chemical methods of extraction and preserves fine details that might otherwise be lost. It is also possible, with practice and while the PVL is hardening, to change the orientation of trophi by gently manoeuvering the coverslip.

Conductivity and pH measurements were made with a Hanna water-test meter.

The Sampling Sites

Whilst this work was in progress, a new map of the Larsemann Hills was issued. On this map, some of the lakes were given official names which are different from those in common usage. Lake Scandrett, for example, was previously known as Lake Nella, Lake Sibthorpe was Lake Mir, and Lake Reid was Big Lake. To avoid confusion over the naming and to identify the unnamed lakes, the "LH" numbering system devised by Gillieson *et al.* (1990) has been used in this paper.

Thirteen lakes on the Stornes and Mirror Peninsulas were sampled (fig. 1). They were picked, within the constraints of accessibility, logistics and time, to cover the range in lake size, depth, pH, conductivity, water chemistry and trophic status, as determined by Gillieson *et al.* (1990); as such, they are thought to be representative of the whole of the Larsemann Hills, even though it was not possible to sample any of the lakes on the offshore islands. None of the lakes is particularly large — Lake Scandrett (LH72) has the largest surface area (13 ha), and Progress Lake (LH57) is easily the deepest at 34 m (Gillieson *et al.* 1990). During the winter, all of the lakes freeze to a depth of 1.5 m. This concentrates the ions, resulting in an increase in the conductivity. This effect is, of course, most marked in shallow lakes, the waters of which become deoxygenated. When the ice melts in the spring, the conductivity falls, and the wind ensures complete mixing and restoration of the oxygen concentration.

The lakes selected for sampling included a very shallow pool — the soak (which was not included in the Gillieson *et al.* (1990) survey), large and deep freshwater lakes, such as Lake Progress, through smaller freshwater lakes, slightly brackish ones (salinities to 2‰ — LH71) and coastal pools that may be subjected to inundation by sea water (LH23).

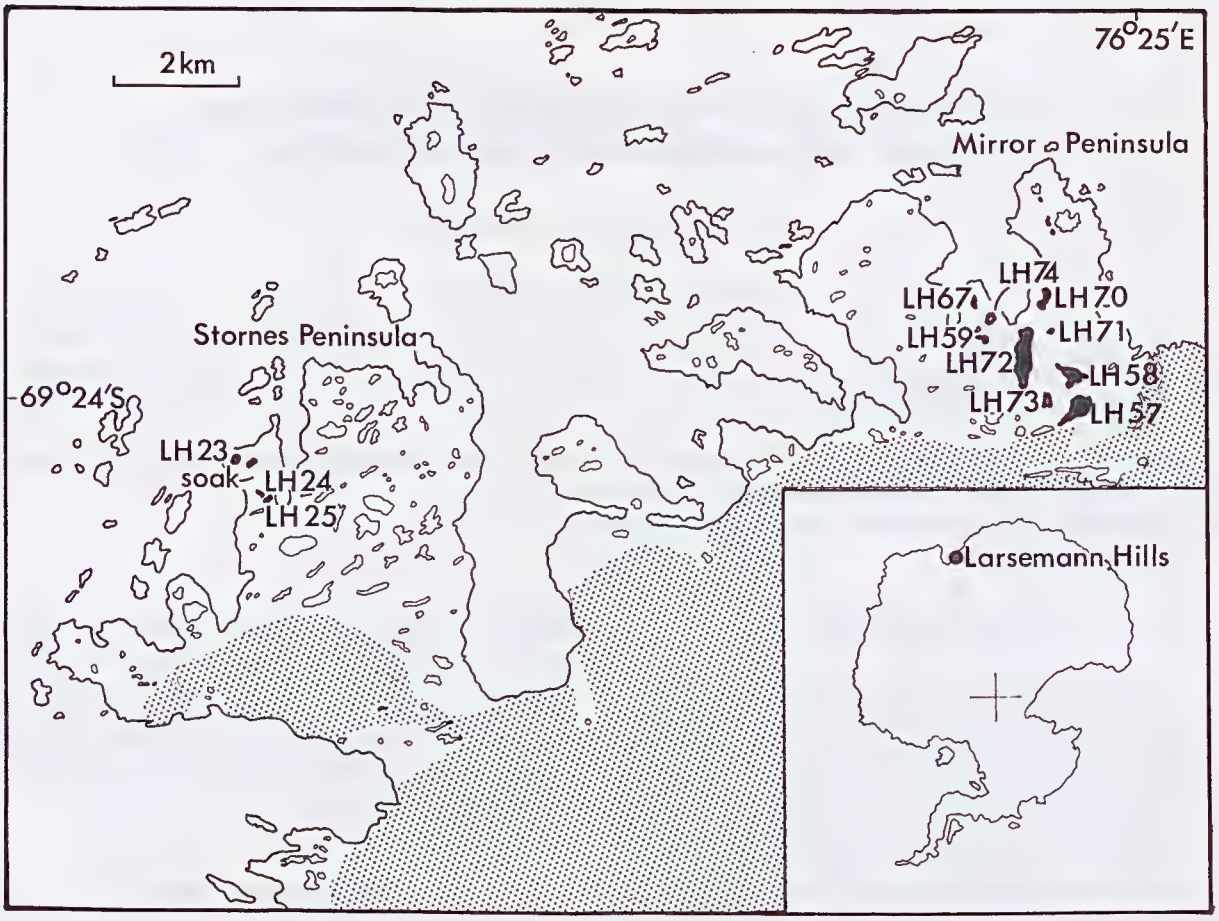

FIG. 1 — Map of the Larsemann Hills showing the location of the lakes (irregular outlines) and the thirteen sampled lakes (filled outlines). The LH numbers refer to the scheme originated by Gillieson et al. *(1990). The area of permanent snow and ice is shaded. The inset map shows the location of the Larsemann Hills in relation to the continent.*

RESULTS

Identification

The Larsemann Hills were visited on five occasions (including visits made for me) during the 1990/91 and 1991/92 summers, and the results of these surveys are given in tables 1 and 2. (The Stornes Peninsula was only visited once, in January 1991.) Since the primary objective of this study was to survey the rotifers, most of the discussion that follows concentrates on rotifer matters. However, the fauna of this area is poorly known, and brief notes on all the invertebrates found are included.

Protozoa

Even though the collecting methods employed were not ideal for protozoa, specimens were observed in most samples. Generally, those seen on the bottom of the freshwater lakes were oval/elliptical, transparent or pale brown ciliates, small ciliates with spikey tufts — holotrichia, large solitary paramecium-type ciliates and a few small amoebae.

Plathyhelminthes

Solitary specimens of a small blind acoel were found in the sediments of Lake Scandrett and LH24 (tables 1, 2).

Tardigrada

At least two species of smooth tardigrade were seen in the freshwater lakes. These would appear to belong to the *Isohysibius* group. In addition *Milnesium tardigradum* Doyere was found in terrestrial mosses at the edge of Lake Scandrett

Rotifera

Many of the species recorded from the Larsemann Hills are common rotifers that are regularly encountered in the Antarctic and elsewhere, and as such require little comment. The section that follows concentrates, therefore, on the more interesting problems of identification and on their distribution.

Monogononta

Eleven species were recognised.

TABLE 1
Distribution* of the invertebrates found in the nine lakes sampled on the Mirror Peninsula

Lake name/ ref. no.†	Scandrett LH72	Discussion LH74	Sibthorpe LH58	Progress LH73	Progress LH57	Progress LH67	Reid LH70	Reid LH59	Reid LH71
Length (m)	945	190	175	225	600	165	300	150	120
Breadth (m)	195	95	165	120	300	75	80	55	60
Max. depth (m)	10.3	4	1	5.4	34	5	3.8	4	2.5
Conductivity µS/cm	88	162	162	286	335	620	1288–167‡	1310	1589
pH	7.0	6.8	6.4	6.9	6.6	7.6	8.4	7.9	8.3
Protozoa	+	+	+	+	+	+	+	+	+
Plathyhelminthes	+	–	–	–	–	–	–	–	–
Tardigrada									
Isohypsibius 2 spp.	+	+	+	–	+	+	+	+	–
Rotifera									
Cephalodella sterea	+	–	+	+	?	–	–	–	–
C. ventripes	+	–	–	–	?	–	–	–	–
Collotheca ornata cornuta	+++	+	–	–	–	–	+	–	–
Encentrum mustela	+	–	–	–	–	–	+	–	–
E. spatitium	+	–	–	–	–	–	+	+	+
Epiphanes senta	–	–	–	–	–	–	+++	+	++
Lepadella patella	+	+	–	+	+	+	+	+	+
L. acuminata	–	–	–	–	–	–	–	–	–
Notholca sp.	+	+	–	+	+	+	+++	+	++
Ptygura crystallina	+	–	–	–	–	–	+	–	–
Resticula gelida	–	–	–	–	–	–	+	–	–
Adineta grandis	–	+	–	–	–	–	++	–	+
Adineta sp.	–	–	–	–	–	–	–	–	–
Habrotrocha constricta	+	–	+	–	–	–	+	–	–
Philodina gregaria	–	–	–	–	–	–	+++	+	–
Philodina sp. 1	++	–	?	–	?	–	+	–	–
Philodina sp. 2	+	+	+	+	+	–	–	–	–
Nematoda	–	+	+	–	–	–	+	–	–
Arthropoda									
Daphniopsis studeri	+++	+	–	–	+	–	+++	–	–
Acanthocylops mirnyi	+	–	–	–	+	–	–	–	–

* Key: – = not found + = present ++ = common +++ = abundant ? = not positively identified.
† The LH (Larsemann Hills) numbers (Gillieson *et al.* 1990).
‡ Higher conductivity recorded in the spring when this lake was ice–covered. Lower value in the summer open-water period.

Epiphanes senta (O.F. Müller)

This species was found in those lakes of higher conductivity and close to the shore (tables 1, 2). Males were found in Lake Reid (LH70) and LH71, which had the largest *E. senta* populations.

Epiphanes senta is cosmopolitan and is usually found in small pools enriched with excreta of domestic animals. In the Antarctic, it is found in pools enriched by penguins and seals. It has been reported from the McMurdo Sound area (Murray 1910, Armitage & House 1962, Dougherty & Harris 1963); from fresh and brackish pools in eastern Antarctica, in the Bunger Hills (Korotkevich 1958), at Haswell Island (Kutikova 1958b, Donner 1972), from the South Shetland Islands (de Paggi 1982) and the South Orkney Islands (Dartnall & Hollowday 1985); from the sub-Antarctic at Macquarie Island (Dartnall 1993); and from Heard Island (Dartnall 1995).

Notholca sp. (fig. 2A, B)

Notholca's were found in every lake except the soak, LH25 and LH58. The specimens from the larger freshwater lakes — Scandrett, Discussion, Sibthorpe and Progress — had a circular/oval lorica 200 µm long, only lightly striated and decorated with six short, anterior spines. Those from the brackish lakes had a "U-shaped" lorica but otherwise were identical (fig. 2A, B). The mastax has malleate trophi. No males were seen.

TABLE 2
Distribution* of the invertebrates found in the four lakes sampled on the Stornes Peninsula

Lake name/ ref. no.†	Soak	LH23	LH25	LH24
Length (m)		105	90	150
Breadth (m)		90	45	60
Depth (m)	0.2	4.6	7.2	4.8
Conductivity µS/cm	146–273	280	822	961
pH	7.6–9.6	7.8	8.6	8.0
Protozoa	+	+	+	+
Plathyhelminthes	–	–	–	+
Tardigrada				
Isohypsibius 2 spp.	+	+	+	+
Rotifera				
Cephalodella sterea	–	–	–	–
C. ventripes	–	–	–	–
Collotheca ornata cornuta	+	+	–	+
Encentrum mustela	–	–	+	–
E. spatitium	+	+	+	–
Epiphanes senta	–	+	–	+
Lepadella patella	+	+	+	+
L. acuminata	–	+	–	–
Notholca sp.	–	++	–	+
Ptygura crystallina	–	–	–	–
Resticula gelida	–	–	–	–
Adineta grandis	–	–	–	+++
Adineta sp.	–	–	–	–
Habrotrocha constricta	+	–	–	–
Philodina gregaria	–	+	–	–
P. sp. 1	+	–	–	–
P. sp. 2	+	–	–	–
Nematoda	+	+	+	+
Arthropoda	–	+++	–	–
Daphniopsis studeri	–	–	–	–
Acanthocylops mirnyi				

* Key: – = not found + = present ++ = common +++ = abundant.
† LH (Larsemann Hills) numbers (Gillieson *et al.* 1990).

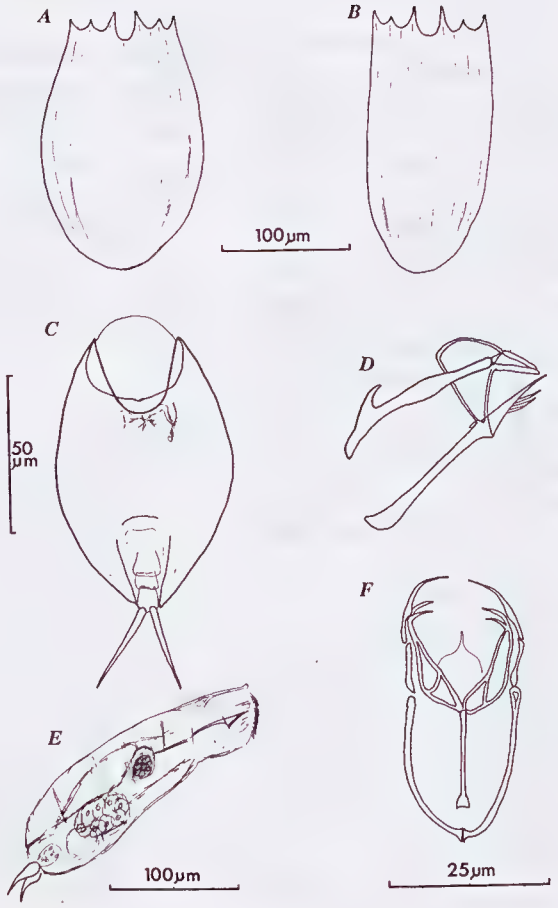

FIG. 2 — (A, B) Notholca *sp., dorsal view of lorica: (A) "freshwater" specimen; (B) "brackish" specimen. (C)* Lepadella acuminata, *ventral view. (D)* Cephalodella sterea: *lateral view of trophi. (E, F)* Encentrum spatitium: *(E) lateral view; (F) trophus of specimen from Lake Scandrett.*

The Larsemann Hills specimens appear to belong to the *squamula/salina* group. *Notholca verae* Kutikova has been reported from the nearby Vestfold Hills (Everitt 1981) and from the Bunger Hills (Kutikova 1958a), and might have been expected to be the species present in the Larsemann Hills. Different species of *Notholca* have been found right round the Antarctic (Dartnall & Hollowday 1985, Dartnall 1993, 1995). Currently the identification of the group is based on morphometric comparisons. Details of the trophi and chemical fingerprinting are obvious areas for future studies.

Lepadella patella (Müller)

One of the commonest rotifers encountered, this was found in all lakes sampled except Lake Sibthorpe.

Lepadella patella is cosmopolitan and has been reported from both Macquarie Island and Iles Kerguelen by Russell in 1959. Other antarctic locations include the Obruchev and Bunger Hills (Korotkevich 1958, Kutikova 1958b), the Thalla Hills (Opalinski 1972b), Langhovde (Sudzuki 1964) and at Heard Island (Dartnall 1995).

Lepadella acuminata (Ehrenberg) (fig. 2C)

Just one specimen was found in LH23. This specimen, which was found in the material collected as *L. patella,* was only recognised when examined under medium power.

Lepadella acuminata is cosmopolitan; in the Antarctic it has been reported from Iles Kerguelen (Russell 1959) and Macquarie Island (Dartnall 1993).

Cephalodella sterea (Gosse) (fig. 2D)

Just a few specimens of this small rotifer were found in four of the freshwater lakes (table 1).

Cephalodella sterea has been reported from the Antarctic before — in the Obruchev Hills (Korotkevich 1958) and at Heard Island (Dartnall 1995).

Cephalodella ventripes (Dixon-Nuttall)

Just one specimen of this species was found in Lake Scandrett. It was amongst the material collected as *C. sterea.*

Cephalodella ventripes has been reported from the Antarctic only once before at Heard Island (Dartnall 1995).

Resticula gelida (Harring & Myers)

Solitary individuals were found Lakes Scandrett and Reid.

Resticula gelida is cosmopolitan and has been reported from Adelaide Island (Dartnall 1980), from brackish pools at Signy Island (Dartnall & Hollowday 1985) and from Heard Island (Dartnall 1995). The closely related *R. nyassa* has been reported from Macquarie Island (Dartnall 1993).

Encentrum spatitium Wulfert (fig. 2E, F)

This species, which is an active predatory rotifer with protrusible forcipate trophi and a soft, elastic body, was found in seven of the lakes sampled (tables 1, 2). The trophi of those specimens from the brackish lakes have a distinctive, chunky appearance, when compared with those from Lake Scandrett, the manubria and intrameallei being particularly broader, but they were identical in all other respects. The small, paired toes have swollen bases.

Encentrum spatitium is a European species of inland saline waters. Its presence in the Larsemann Hills lakes was therefore surprising, being the first report in the Southern Hemisphere. However, it was also found in some of the saline lakes in the Vestfold Hills and, as will be described in a future paper, in coastal pools on South Georgia.

Encentrum mustela (Milne)

This species was found in just two of the lakes on the Mirror Peninsula (table 1). Like *E. spatitium,* it is a solitary, predatory species. In Europe it is regarded as a cold stenotherm.

Encentrum mustela probably has a circumpolar antarctic distribution. It has been reported from Signy Island (Dartnall & Hollowday 1985), from Macquarie Island (Dartnall 1993) and from Heard Island (Dartnall 1995).

Ptygura crystallina (Ehrenberg)

This species was found in in just two of the lakes on the Mirror Peninsula (table 1).

Ptygura crystallina is a cosmopolitan species, which has been reported from the Antarctic and Subantarctic four times before; from Signy Island (Dartnall & Hollowday 1985), from the Vestfold Hills (identified as *Ptygura* sp. by Everitt [1981] but now confirmed as *P. crystallina*) and from Macquarie Island (Dartnall 1993).

Collotheca ornata cornuta (Dobie)

Collotheca ornata cornuta has a worldwide distribution. It has been reported from the antarctic region several times and undoubtedly has a circumpolar distribution. It was first recorded in 1910 (reported as *Floscularia cornuta*) by Murray, who found it at Cape Barne and Cape Royds (Murray 1910), and has subsequently been reported from these locations and nearby by Armitage & House (1962), though their record is for *C. ornata,* and by Dougherty & Harris (1963). It has been reported from eastern Antarctica from pools in the Obruchev Hills (Korotkevich 1958, Kutikova 1958b), from Signy Island (Dartnall & Hollowday 1985), from Macquarie Island (Dartnall 1993) and from Heard Island (Dartnall 1995).

Bdelloidea

Six species of bdelloid rotifer were recognised.

Adineta grandis Murray

This large (to 700 μm) brown rotifer was only found in those lakes with the highest conductivities. It is a viviparous species and some specimens were observed to have five developing young in their bodies. As with all members of the genus, the normal bdelloid wheel organ is absent and consequently all Adinetids creep or glide over the bottom and do not swim.

Adineta grandis is only found in the Antarctic and probably has a circumpolar distribution. So far it has been reported from the McMurdo Sound area (Murray 1910, Dougherty & Harris 1963, Spurr 1975), from Haswell Island (Donner 1972, Opalinski 1972a) and from Signy Island (Dartnall & Hollowday 1985)

Adineta sp.

Only a few specimens of this species were found, in Lakes Scandrett and Discussion. It is a relatively small (250 μm), transparent species with no distinguishing marks and may therefore be a juvenile.

Habrotrocha constricta Dujardin

This pellet-forming bdelloid was seen creeping on the bottom of a number of lakes (tables 1, 2). Of medium size (up to 400 μm) the body was smooth and a pale yellow-brown. The ramate trophi are covered with fine striae and have a characteristic dental formula of 8/8 unci teeth. Several oval eggs (80 × 50 μm) were seen.

According to Bartos (1951), *Habrotrocha constricta* is cosmopolitan and it has been reported from the Antarctic several times. It was first reported by Murray (1910) from the McMurdo Sound area and has subsequently been reported at Signy Island (Jennings 1976, Donner 1980, Dartnall & Hollowday 1985) and the Vestfold Hills (Everitt 1981).

Philodina gregaria Murray

This very large rotifer, which is in excess of 600 μm long and is bright red with a pair of conspicuous, orange eye-spots, was found in lakes with the higher conductivities on the Mirror Peninsula (table 1) and in LH23 on the Stornes Peninsula (table 2).

Like *Adineta grandis, Philodina gregaria* is only found in the Antarctic. Descibed by Murray in 1910 from the lakes and pools at Cape Royds and Cape Barne, it has been reported from Haswell Island (Donner 1972, Opalinski 1972a); from the Vestfold Hills (Everitt 1981); on the Antarctic Peninsula, at Red Rock Ridge, Stonington (Schmitt 1945) and at Ablation Point, Alexander Island (Heywood 1977); and at Signy Island (Dartnall & Hollowday 1985).

Philodina sp. 1

This large (> 400 μm), brown bdelloid was most common in Lake Scandrett. It was most numerous on the bottom, but a number of specimens were distributed throughout the water column (first visit when the lake was covered with ice 0.9 m thick). It is a very chunky species with a large pair of cilary discs and orange eye-spots; the trophi had a dental formula of 3/3 or 3 + 1/3 + 1. The dorsal antennae appear to be two-segmented. An oviparous species, it lays pale-brown, oval eggs with a single polar knob (100 × 75 μm).

Philodina sp. 2

This species is much smaller (300 μm long) and slimmer than *Philodina* sp. 1, pale red, and with a 2/2 dental formula. It was found in relatively small numbers in the larger freshwater lakes (table 1) and the soak (table 2).

Nematoda

Nematodes were found in the benthic sediments of a number of lakes. Two species, unidentified, were recognised in the field.

Arthropoda

Just two species were present in the freshwater lakes; the cladoceran *Daphniopsis studeri* Rühe and the copepod *Acanthocyclops mirnyi* Borutzky and Vinogradov. *Daphniopsis studeri* was the largest and most abundant species found. Large numbers of males were found in Lake Scandrett during the February visit. This species is commonly recorded from the subantarctic islands of the Southern Indian Ocean. *Acanthocyclops mirnyi* was also found in the larger freshwater lakes. It was first found in the Bunger Hills (Korotkevich 1958).

DISCUSSION

Overall, the range of lake types is not particularly great and the fauna is essentially similar throughout. Nevertheless, it is possible to discern certain correlations between habitat and fauna. Thus, both species of *Cephalodella, Philodina* sp. 1 and the copepod *Acanthocyclops mirnyi* are found in the freshest lakes while *Epiphanes senta, Adineta grandis* and *Philodina gregaria* predominate in those with a higher conductivity (brackish)

Although protozoans, turbellarians, gastrotrichs, nematodes, rotifers, tardigrades, annelids and arthropods have all been reported from lakes and pools on the subantarctic islands and from the Antarctic Continent (Heywood 1967, 1972), they are not distributed throughout the antarctic region, and Dartnall & Heywood (1980) have noted a decline in their variety with increasing latitude. Indeed, gastrotrichs, annelids and, amongst the arthropods, anostracans, ostracods, collembolans and mites are entirely absent from the Larsemann Hills lakes.

Even those ubiquitous groups that are present show a marked decline in the number of species, when compared with more northerly locations. Thus, there is only one species of cladoceran and one copepod in the Larsemann Hills, compared with the five cladocerans and three copepods at South Georgia (Dartnall & Heywood 1980); three cladocerans and two copepods at both Signy (Heywood, Dartnall & Priddle 1979) and Macquarie Island (Evans 1970 and the late D.G. Frey, pers. comm.); and four cladocerans and two copepods at Heard Island (Dartnall 1995). This difference is even more marked for the rotifers with 55 species at South Georgia (from a recent unpublished survey), 39 at Macquarie Island (Dartnall 1993) and 38 at Signy Island (Dartnall & Hollowday 1985), compared with the 17 recorded in the present survey.

On the Antarctic Continent only the McMurdo Sound area with 20 rotifer species (Murray 1910, Dougherty & Harris 1963, Donner 1972, Cathey *et al.* 1981) has a comparable list. Rotifers have been reported from several other continental antarctic locations, but these are incomplete surveys and list less than eight species (for a complete review, see Dartnall & Hollowday 1985). These incomplete surveys invariably record *Epiphanes senta, Adineta grandis, Habrotrocha constricta* and *Philodina gregaria.* All of the rotifers found in the Larsemann Hills have been reported from or, in the case of *Encentrum spatitium,* have subsequently been found in the Antarctic/sub-Antarctic,

The finding of more species of Monogononta (11) than Bdelloidea (6), though a lower ratio than the 28:9 recorded for Signy Island (Dartnall & Hollowday 1985), does confirm their observation that Monogononta are the dominant rotifer group in antarctic aquatic habitats, and finally lays to rest Murray's 1910 observation (where the ratio was 6:14), and the subsequent prevalent view that bdelloids are the principal rotifer group in the Antarctic. Even so the bdelloid *Philodina gregaria* remains easily the most abundant species.

The lakes and pools of the Larsemann Hills provide a series of fresh to slightly brackish habitats that are readily accessible and contain a rich and varied fauna very typical of the Antarctic region. As one might expect, the fauna includes the endemic rotifers *Philodina gregaria* and *Adineta grandis* plus a number of cosmopolitan ones. Of special interest, however, is the presence of the rotifers *Cephalodella sterea* and *C. ventripes,* also reported from Heard Island

(Dartnall 1995), and of the copepod *Daphniopsis studeri,* which is found on the subantarctic islands of the southern Indian Ocean, because of the links these distributions indicate.

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THE VEGETATION OF DOVER AND ERITH ISLANDS, KENT GROUP, BASS STRAIT

by J.B. Kirkpatrick

(with three tables, one text-figure and four plates)

KIRKPATRICK, J.B., 1995 (30:vi): The vegetation of Dover and Erith Islands, Kent Group, Bass Strait. *Pap. Proc. R. Soc. Tasm.* 129: 25–33. ISSN 0800–7403. Department of Geography and Environmental Studies, University of Tasmania, Box 252C, GPO, Hobart, Tasmania, Australia 7001.

The terrestrial vegetation of Dover and Erith Islands is comprised of low forest dominated by *Allocasuarina verticillata* or Myrtaceae species (including *Eucalyptus nitida, Melaleuca ericifolia* and *Leptospermum laevigatum*), closed-scrub, heath, *Poa poiformis* tussock grassland and a wide variety of coastal vegetation types. While Dover Island, which is infrequently burned and ungrazed by stock, is largely covered by low forest, closed-scrub and heath which almost totally lack exotics, Erith Island, which is frequently burned and grazed by cattle, is largely covered by *P. poiformis* tussock grassland with a high proportion of introduced species. Variation in the less disturbed vegetation of the two islands largely relates to soil nutrient conditions, as indicated by pH, soil drainage and exposure to salt-laden winds. Both islands have significant nature conservation values.

Key words: islands, vegetation, disturbance, edaphic ecology, Bass Strait.

INTRODUCTION

During the many and protracted periods colder than today that have characterised the Quaternary, Bass Strait was largely dry land. The numerous islands of today provided relative relief in a broad windswept plain. The islands differ markedly in their floras and plant communities (Guiler *et al.* 1958, Kirkpatrick *et al.* 1974, Scarlett *et al.* 1974), with the presence of particular species and communities providing clues to the nature of the complex migration paths that seem to have occurred as sea level rose. For example, the presence of *Eucalyptus globulus* ssp. *pseudoglobulus* on Rodondo Island and northern Flinders Island does not fit neatly with environmental gradients (Jordan *et al.* 1993). The islands also differ markedly in their degree of disturbance by human activities. All were uninhabited when Europeans arrived to settle in Australia. Most islands were subsequently burned and stocked. The few islands that escaped, or largely escaped European disturbance have few exotic plant species, while a substantial proportion of the the flora of the most disturbed islands consists of introduced plants (Kirkpatrick 1993).

Although the vegetation of Dover and Erith Islands (fig. 1) has been described at a general level (Mullet & Murray-Smith 1967, Marginson & Murray-Smith 1969), and been collected by John Whinray and others, like most Bass Strait islands, these have escaped thorough vegetation survey. Despite the fact that the two islands are linked at low tide, they contrast markedly in their degree of disturbance. Dover, although occasionally burned, has not been grazed by stock or cleared. Erith has been grazed and frequently burned, in order to replace scrub with grass, since the early days of settlement in Bass Strait. This very different disturbance history can be readily explained by the relatively greater extent of soils formed on calcarenite on Erith and the relative steepness and rockiness of Dover.

This paper reports the results of a quadrat-based vegetation survey of the two islands, explores the environmental relationships of the plant communities and discusses the significance of the vegetation of the two islands for conservation.

METHODS

The vegetation of the islands was surveyed in March 1994, using 10 x 10 m quadrats located to encompass variation in dominance and structure, as perceived on aerial photographs, on several traverses of both islands. A vegetation map was drawn, using these aerial photographs and information from ground survey, including oblique photographs taken in the field.

At each quadrat location the following data were recorded: all observable higher plant species, the height and cover of the dominant stratum, the dominant species, the altitude, slope, aspect, surface pH and % rockiness. Aspect was divided into five classes related to the degree of drying to be expected from the sun (1, northwest; 2, north and west; 3, northeast and southwest; 4, south and east; 5, southeast). Because of the time of year in which sampling took place, some annuals and geophytes, such as *Bulbine bulbosa* and *B. semibarbata* and the 15 orchid species known from the islands (Beth Gott, pers. comm.), would have been missed.

The floristic data were sorted using the polythetic divisive programme TWINSPAN (Hill 1979) and nine communities were selected from this matrix. Percentage frequencies of species in each of these groups were calculated. Means, standard deviations, 25 percentiles and ranges were calculated for the quadrats in all groups with more than three individuals, and for species occurring in ten or more quadrats for altitude, slope, aspect, pH, vegetation height and rockiness. Data on dominance was tabulated by floristic community.

Species nomenclature follows Hnatiuk (1990) and structural nomenclature follows Specht (1981).

RESULTS AND DISCUSSION

Vegetation mapping

Ten mapping units were discriminated (fig. 1). One unit, *Myoporum insulare* shrubland/open-scrub, is confined to Erith, where it typically consists of clumps of 2–4 m tall shrubs of *M. insulare*, separated by areas dominated by

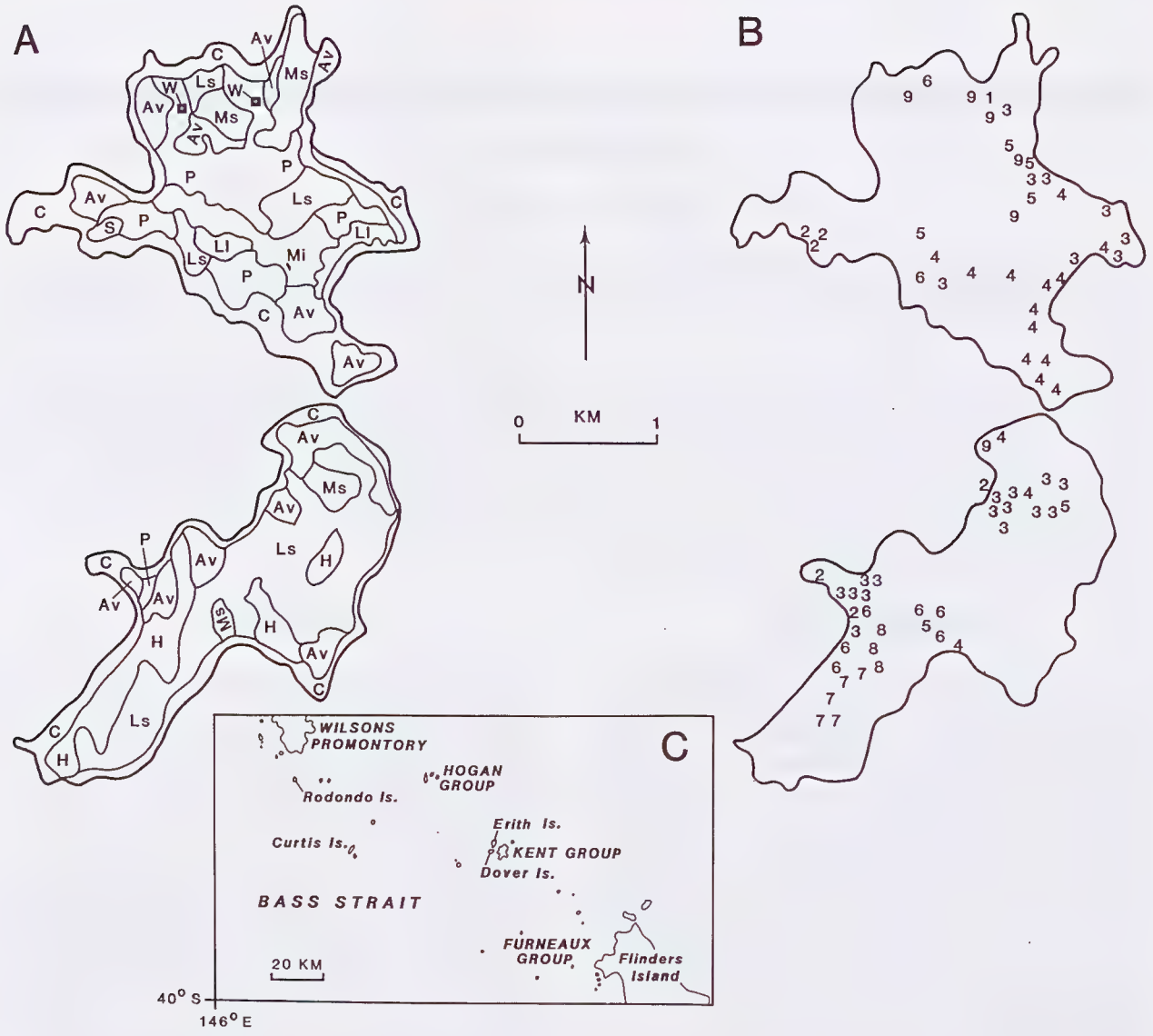

FIG. 1 — (A) Vegetation map. Av = Allocasuarina verticillata *open/closed-forest; C = coastal complex; H = heath; Ll* = Leptospermum laevigatum *closed-scrub; Ls* = Leptospermum scoparium–Kunzea ambigua *closed-scrub; Mi* = Myoporum insulare *shrubland/open-scrub; Ms* = Melaleuca ericifolia *closed heath/scrub/forest; P* = Poa poiformis *tussock grassland; S* = Stipa stipoides *tussock grassland, W = wetland. (B) The distribution of quadrats in each classificatory group. (C) The location of the study area and places mentioned in the text.*

either *Poa poiformis* or *Lepidosperma gladiatum* (pl. 1). These latter two species have understories dominated by exotic grasses and herbs. This mapping unit probably represents a stage in the re-invasion of culturally induced *P. poiformis* tussock grassland. *M. insulare* does not burn readily and is not grazed by the cattle present on Erith. The unit is confined to calcareous sands over calcarenite.

Two small wetlands fed by springs in the calcarenite occur on Erith Island. Their vegetation is dominated by *Juncus* species. The understorey contains a variety of native and exotic herbs (table 1, community 1).

Poa poiformis tussock grassland (pl. 2) is more widespread on Erith than on Dover. It varies in its structure from closed to open, depending on grazing pressure. On Erith Island, the understorey to the tussocks is largely dominated by exotic species. On Dover, the understorey taxa are largely native. Some of the area mapped in this unit has vegetatively resprouting individuals of *Melaleuca ericifolia*, indicating that, in the absence of further fire, it would become closed-scrub/low closed-forest. On Dover, this vegetation type is only found in situations close to sea level and exposed to considerable salt spray.

Stipa stipoides tussock grassland is widespread around the coasts of both islands but is mostly too localised to be mappable at the scale used. It usually occurs between a zone dominated by succulents and *P. poiformis* tussock grassland. *S. stipoides* often has a succulent understorey.

The coastal complex includes both rocky shore and foredune vegetation, the latter being confined to Erith, as Dover has no beaches. Dominance is highly variable. On the foredune at Erith, *Spinifex sericeus, Austrofectuca littoralis* and *Helichrysum paralium* are variously dominant. Where birds nest, *Tetragonia implexicoma* is often dominant. On calcareous clifftops, *Beyeria leschenaultii, Calocephalus*

PLATE 1
Myoporum insulare *shrubland/open-scrub on Erith Island.*

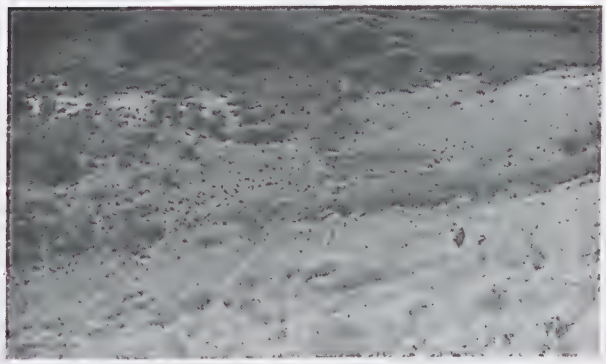

PLATE 2
Poa poiformis *tussock grassland on Erith Island on calcarenite with* Allocasuarina verticillata *low forest and* Melaleuca–Leptospermum *closed-scrub on the granite in the background.*

PLATE 3
Allocasuarina verticillata *low forest on Erith Island. Deal Island is in the background.*

PLATE 4
Heath on Dover Island. The large bushes are Banksia marginata.

brownii and *Pomaderris paniculosa* are among the many dominants. In highly exposed granite cracks, *Apium insulare* or *Ixiolaena supina* are often dominant. One small area of *Sarcocornia quinqueflora* succulent herbfield was noted on Erith.

Allocasuarina verticillata dominates open to closed low forest (pls 2, 3) on both islands in rocky places sheltered from the fiercest of the salt-laden winds and with soils of moderate to high pH. The understorey is highly variable but usually shrubby, although the oldest trees found on Dover had an understorey of dead branches and cladodes entwined with *Clematis microphylla.*

Three types of closed-scrub/low closed-forest are mapped. The first has substantial cover of *Melaleuca ericifolia,* which occurs variably with *Leptospermum laevigatum, L. scoparium, Kunzea ambigua, Eucalyptus nitida* (not on Erith) and *Monotoca elliptica.* The second type consists of a closed-scrub/closed-forest dominated by *L. laevigatum,* which constitutes almost all of its biomass. This community is confined to calcareous soils on Erith. The third type of closed-scrub/closed-forest is dominated by varying combinations of *L. scoparium, E. nitida* (not on Erith), *Kunzea ambigua, Callitris rhomboidea* and *M. elliptica.* It is found on weakly acid ground on both islands.

The final mapping unit is heath (pl. 4), which varies from open to closed in structure and has highly variable dominance. Some of the more prominent species in the tallest stratum are *Callitris rhomboidea, Leptospermum scoparium, Calytrix tetragona, Epacris impressa* and *Aotus ericoides.* It is characteristic of shallow, rocky soils at relatively high altitude.

TABLE 1
The percentage frequency of species by floristic community and island

Species	Community									Island	
	8	7	5	6	3	9	2	1	4	Dover	Erith
Acacia mucronata	33	20	17	-	-	-	-	-	-	8	-
Acacia verticillata	-	-	17	12	-	17	-	-	-	-	8
**Agropyron littoralis*	-	-	-	-	-	-	-	-	6	-	3
Agrostis spp.†	-	-	-	-	9	-	33	-	-	17	-
**Aira caryophyllea*	-	-	67	-	9	83	-	-	6	3	31
Allocasuarina monilifera	100	20	-	-	-	-	-	-	-	11	-
Allocasuarina verticillata	-	40	67	50	39	33	-	-	19	34	31
Alyxia buxifolia	-	-	33	87	74	17	33	-	62	66	39
**Anagallis arvensis*	-	-	-	-	-	33	-	-	6	-	8
Aotus ericoides	100	100	-	-	-	-	-	-	-	21	-
Apalochlamys spectabilis	-	-	-	-	-	33	-	-	-	-	6
Apium insulare	-	-	-	-	-	-	50	-	-	3	6
Apium prostratum	-	-	-	-	-	-	33	100	12	-	14
**Aster subulata*	-	-	-	-	-	-	-	100	-	-	3
**Atriplex* sp.	-	-	-	-	-	-	-	100	-	-	3
Austrofestuca littoralis	-	-	-	-	-	-	-	-	6	-	3
Banksia marginata	33	-	-	-	-	-	-	-	-	3	-
Baumea acuta	100	40	-	12	-	-	-	-	-	16	-
Beyeria leschenaultii	-	-	-	-	4	16	-	-	6	5	3
Brachyscome diversifolia	-	-	33	-	30	17	33	-	25	24	19
**Bromus diandrus*	-	-	-	-	35	17	-	-	31	18	19
**Bromus mollis*	-	-	-	-	-	-	-	-	12	-	6
**Cakile* sp.	-	-	-	-	-	-	-	-	6	-	3
Callitris rhomboidea	67	100	33	37	-	-	-	-	-	24	8
Calocephalus brownii	-	-	-	-	4	-	67	-	50	13	22
Calytrix tetragona	100	80	33	62	9	17	17	-	12	37	17
Carpobrotus rossii	-	-	-	12	30	-	33	-	25	16	22
**Centaurium* sp.	-	-	33	-	-	83	-	-	6	-	22
**Cheiranthus* sp.	-	-	-	-	4	-	-	-	-	-	3
Chenopodium glaucum	-	-	-	-	-	-	-	100	-	-	3
Clematis microphylla	-	-	-	-	18	-	-	-	6	8	6
Comesperma volubile	-	-	-	-	-	17	-	-	12	3	6
Correa reflexa	-	-	50	50	30	17	33	-	75	37	42
Cotula coronopifolia	-	-	-	-	-	-	-	100	-	-	3
Crassula sieberiana	-	-	33	12	4	-	50	-	6	11	11
Cyathodes juniperina	-	40	50	75	35	-	17	-	12	45	14
**Cynosorus* sp.	-	-	-	-	-	-	-	100	-	-	3
**Dactylis glomerata*	-	-	-	-	-	-	-	-	12	-	6
Danthonia spp.‡	-	-	17	12	4	33	-	-	12	8	19
Daucus glochidiatus		20	-	-	-	17	-	-	-	3	3
Dianella revoluta	-	-	-	12	35	33	-	-	19	16	22
Dichelachne crinita		-	17	-	4	50	-	-	12	-	19
Dichondra repens		-	-	-	13	67	-	-	56	-	44
Dillwynia glaberrima	33	-	-	-	-	-	-	-	-	3	-
Disphyma crassifolium	-	-	-	-	22	-	100	-	6	21	11
Drosera pygmaea	33	-	-	12	-	-	-	-	-	5	-
**Ehrharta erecta*	-	-	-	-	4	-	-	-	-	-	3
Epacris impressa	100	80	-	37	-	-	-	-	-	21	6
Epilobium billardierianum	-	-	-	-	-	-	-	100	-	-	3
Eucalyptus nitida	67	60	-	12	-	-	-	-	-	16	-
Galium australe	-	-	17	-	9	-	-	-	6	11	3
Geranium sp.	-	-	-	-	-	-	-	19	-	-	3
Gnaphalium gymnocephalum	-	-	-	-	-	33	-	-	6	-	8
Goodenia ovata	-	-	83	100	82	67	-	-	12	58	44
Helichrysum dendroideum	-	-	-	-	-	33	-	-	-	-	6
Helichrysum paralium	-	-	-	25	9	17	33	-	37	21	14
**Holcus lanatus*	-	-	-	-	-	17	-	-	6	-	6
Isolepis cernua	-	-	-	-	-	-	-	100	-	-	3
Isolepis nodosa	-	-	-	-	-	67	17	-	25	5	19

Species	Community									Island	
	8	7	5	6	3	9	2	1	4	Dover	Erith
Ixiolaena supina	-	-	-	12	-	-	33	-	6	3	8
Juncus kraussii	-	-	-	25	-	-	-	100	-	5	3
Juncus pallidus	-	-	-	-	4	17	-	100	-	3	3
Juncus pauciflorus	-	-	-	-	-	17	-	100	-	-	3
Kunzea ambigua	-	-	17	-	13	-	-	-	-	11	-
Lagenifera stipitata	-	-	-	-	-	17	-	-	-	-	3
**Lagurus ovatus*	-	-	-	-	-	-	-	-	31	-	14
**Leontodon sp.*	-	-	-	-	4	33	-	-	31	-	22
Lepidosperma concavum	100	100	-	-	-	-	-	-	-	21	-
Lepidosperma gladiatum	-	-	-	-	-	17	-	-	50	8	17
Leptospermum laevigatum	3	100	100	50	30	33	-	-	25	47	31
Leptospermum scoparium	100	40	67	75	4	50	-	-	-	24	28
Leucopogon lanceolatus	-	-	50	12	13	33	-	-	-	11	14
Leucopogon parviflorus	-	-	17	-	22	17	17	-	69	8	44
Lilaeopsis polyantha	-	-	-	-	-	-	-	100	-	-	3
Lobelia alata	-	-	-	-	-	-	-	100	19	-	11
**Lolium perenne*	-	-	-	-	-	17	-	-	19	-	11
Melaleuca ericifolia	-	20	83	62	13	33	-	-	-	26	17
** Melilotus indica*	-	-	-	-	-	-	-	-	50	-	22
*Monotoca*spp.	67	100	-	37	-	-	-	-	-	27	-
Myoporum insulare	-	-	-	-	30	-	-	-	19	11	17
Olearia phlogoppapa	-	-	17	12	78	33	-	-	31	47	25
Olearia ramulosa	-	-	17	-	-	50	-	-	-	-	11
Olearia viscosa	-	-	-	-	9	-	-	-	-	3	3
Oxalis perennans	-	-	-	-	-	-	-	-	6	-	3
Parietaria debilis	-	-	-	-	-	17	-	-	-	-	3
Pimelea linifolia	67	40	-	37	4	-	-	-	6	13	11
**Plantago coronopus*	-	-	17	-	-	50	-	100	6	-	17
Poa poiformis	-	-	83	62	70	100	33	-	56	50	67
Pomaderris paniculosa	-	-	-	-	-	17	-	-	12	5	3
Pseudognaphalium luteoalbum	-	-	-	-	-	17	-	-	6	-	6
Pteridium esculentum	-	-	-	-	4	33	-	-	6	-	11
Pultenaea daphnoides	100	100	67	87	17	17	-	-	-	42	22
Rhagodia candolleana	-	-	-	-	70	-	17	-	69	34	42
Sambucus gaudichaudiana	-	-	-	-	4	-	-	-	-	3	-
Sarcocornia quinqueflora	-	-	-	-	-	-	33	-	-	-	6
Senecio sp.	-	-	-	-	4	50	-	-	-	3	8
**Senecio elegans*	-	-	-	-	-	-	-	-	19	-	8
Senecio lautus	-	-	-	-	13	-	17	-	-	-	11
Solanum sp.	-	-	-	-	-	-	-	-	6	-	3
**Sonchus asper*	-	-	-	-	22	17	33	-	56	13	33
Sonchus megalocarpus	-	-	-	-	-	-	-	-	6	-	3
**Sonchus oleraceus*	-	-	-	-	4	-	-	-	12	-	8
Spinifex sericeus	-	-	-	-	-	-	-	-	6	-	3
Stackhousia monogyna	-	-	-	-	-	17	-	-	6	-	6
Stipa flavescens	-	-	-	-	4	-	-	-	25	-	14
Stipa stipoides	-	-	-	-	9	-	100	-	19	16	14
Stylidium graminifolium	-	100	17	75	4	17	17	-	-	32	8
Swainsonia lessertifolia	-	-	-	-	-	17	-	-	31	3	14
Tetragonia implexicoma	-	-	-	-	48	-	-	-	56	24	31
Threlkeldia diffusa	-	-	-	-	4	-	-	-	25	3	11
**Trifolium dubium*	-	-	-	-	-	67	-	-	44	-	31
Urtica incisa	-	-	-	-	4	-	-	-	6	-	6
**Vellereophyton dealbatum*	-	-	-	-	4	17	67	-	6	11	8
**Vulpia* sp.	-	-	33	-	4	-	-	-	-	3	6
Wahlenbergia sp.	-	-	-	-	-	17	-	-	-	-	3
Zygophyllum billardieri	-	-	-	-	-	-	-	-	31	-	14

* Non-native species.

† Includes *Agrostis aemula* and *A. avenacea.* ‡ Includes *Danthonia caespitosa* and *D. penicillata.*

Characteristics and environments of floristic communities

The percentage frequency of species in each of the classificatory groups is shown in table 1. Table 2 gives environmental, species richness and height data. The distributions of dominant species among communities is shown in table 3. The distributions of the quadrats in the communities are shown in figure 1. Species occurring in more than 60% of the quadrats in a community are listed by lifeform in the descriptions of the communities below.

1. *Juncus* rushland

Introduced grass: *Cynosorus echinatus*
Native graminoids: *Isolepis cernua, Juncus kraussii, J. pallidus, J. pauciflorus*
Native herbs: *Apium prostratum, Chenopodium glaucum, Cotula coronopifolia, Epilobium billardierianum, Lilaeopsis polyantha, Lobelia alata*
Introduced herbs: *Aster subulata, Atriplex* sp., *Plantago coronopus*
This community occurred in only one quadrat. However, its environmental differentiation from other communities is strikingly clear. With constant seepage from a permanent spring of water with a pH of 8.5, the community occupies a distinct and highly localised environment. It is being damaged by cattle trampling, which has caused extensive puddling. Both areas observed of this community are in a matrix of *Poa poiformis* tussock grassland.

2. *Stipa stipoides/Calocephalus brownii* tussock grassland/shrubland

Native shrubs: *Calocephalus brownii*
Native grasses: *Stipa stipoides*
Native succulents: *Disphyma crassifolium*
Introduced herbs: *Vellereophyton dealbatum*
This coastal community is associated with alkaline soils and high inputs of salt spray. *Stipa stipoides* is the most frequent dominant. It occurs to the seawards of all other communities (fig. 1).

3. *Allocasuarina verticillata–Alyxia buxifolia* low open-forest/open-heath

Native shrubs: *Alyxia buxifolia, Goodenia ovata, Olearia phlogopappa*
Native succulents: *Rhagodia candolleana*
Native grasses: *Poa poiformis*
This coastal community occurs on more acid soils than either of community 2 or 4, usually on a jumble of granite boulders. *Allocasuarina verticillata* and *Leptospermum laevigatum* are the most frequent dominants among a large number.

4. *Leucopogon parviflorus–Rhagodia candolleana* open-heath

Native shrubs: *Alyxia buxifolia, Correa reflexa, Leucopogon parviflorus*
Native succulent: *Rhagodia candolleana*
This coastal community usually occurs on more calcareous soils than community 3. *Leptospermum laevigatum* is the most frequent dominant, although dominance is highly variable.

5. *Allocasuarina verticillata–Leptospermum scoparium* low forest

Native trees: *Allocasuarina verticillata*
Native shrubs: *Goodenia ovata, Leptospermum laevigatum, L. scoparium, Melaleuca ericifolia, Pultenaea daphnoides*
Native grasses: *Poa poiformis*
Introduced grasses: *Aira caryophyllea*
This community varies from heath to low forest and can be open or closed. It is usually dominated by *Leptospermum scoparium* or *Allocasuarina verticillata*. It occurs in the rockiest situations of the non-coastal communities, invariably on slightly acid soils on granite and at lower altitudes than communities 7 and 8.

6. *Melaleuca ericifolia–Leptospermum scoparium* closed-scrub

Native shrubs: *Alyxia buxifolia, Calytrix tetragona, Cyathodes juniperina, Goodenia ovata, Leptospermum scoparium, Melaleuca ericifolia, Pultenaea daphnoides*
Native grasses: *Poa poiformis*
Native herbs: *Stylidium graminifolium*
This community forms a dense closed-scrub, mostly dominated by *M. ericifolia* or *Allocasuarina verticillata*, generally on southerly, steep, rocky slopes on slightly acid soils. It occurs at lower altitude than communities 7 and 8.

7. Dry heath

Native shrubs: *Aotus ericoides, Callitris rhomboidea, Calytrix tetragona, Epacris impressa, Leptospermum laevigatum, Monotoca elliptica, Pultenaea daphnoides*
Native graminoids: *Lepidosperma concavum*
Native herbs: *Stylidium graminifolium*
This open-heath community is usually dominated by *Leptospermum scoparium* or *Eucalyptus nitida*. It occurs on the northerly and westerly aspects and ridges of the granite peaks on highly acid and rocky soils. It intergrades with community 8 as drainage becomes more impeded and with community 6 downslope.

8. Wet heath

Native shrubs: *Allocasuarina monilifera, Aotus ericoides, Callitris rhomboidea, Calytrix tetragona, Epacris impressa, Eucalyptus nitida, Leptospermum scoparium, Monotoca elliptica, Pimelea linifolia, Pultenaea daphnoides*
Native graminoids: *Baumea acuta, Lepidosperma concavum*
This open to closed-heath community occurs on acid soils with the organically enriched A horizon, lack of rock cover and gentle slopes that often indicate periods of poor drainage. It intergrades with community 7 as drainage improves, and with community 6 downslope. Different dominant species are found in each of the three quadrats in the group.

TABLE 2
Means, standard deviations and ranges for environmental and structural variables by community

Community	1(1)	2(6)	3(23)	4(16)	5(6)	6(8)	7(5)	8(3)	9(6)
Aspect mean (s.d.) range	2	2.3 (1.4) 1-4	2.9 (2.7) 1-5	2.94 (0.93) 1-4	2.8 (1.6) 1-5	3.0 (1.9) 1-5	2.4 (1.5) 1-5	1.3 (0.5) 1-2	2.5 (1.4) 1-5
Slope	8	21.8 (14.6) 3-40	15.1 *8.6) 2-30	19.25 (11.22) 3-45	15.7 (10.3) 5-34	25.7 (8.6) 15-40	14.6 (4.6) 10-20	9.0 (1.7) 7-10	18.3 (8.8) 5-25
pH	8	7.7 (1.5) 6-9.5	6.2 (1.1) 4.5-9.5	8.7 (1.2) 6-9.5	5.0 (0.5) 4.5-5.5	5.1 (0.7) 4.5-6.0	4.8 (0.4) 4.5-5.5	4.5 (0.0)	6.7 (1.5) 5.5-9.5
Altitude	40	31 (16) 5-50	46 (34) 5-120	53 (39) 2-140	87 (31) 60-140	92 (28) 50-120	172 (45) 120-220	150 (10) 140-160	67 (20) 40-100
Rock cover	0	40 (41) 0-90	24 (24) 0-70	18 (30) 0-90	35 (34) 0-80	33 (41) 0-80	34 (36) 0-80	2 (3) 0-5	12 (12) 0-30
Richness	12	21.8 (14.6) 3-16	10.3 (2.4) 6-16	15.4 (6.4) 6-32	11.8 (2.0) 9-15	11.7 (3.0) 6.16	12.2 (1.6) 10-14	12.3 (1.1) 11-13	17 (4.3) 12-22
Vegetation height	0.4	0.2 (0.1) 0.1-0.3	2.9 (2.7) 0.1-8.0	2.0 (2.7) 0.1-8.0	2.7 (2.3) 0.4-6.0	2.3 (1.4) 0.1-4.0	1.0 (1.4) 0.2-3.5	1.8 (1.2) 0.5-3.0	0.3 (0.1) 0.2-0.5

TABLE 3
Dominants as a percentage of quadrats by classificatory group

	Classificatory group								
Dominant species	8	7	5	6	3	9	2	4	1
Juncus kraussii	-	-	-	-	-	-	-	-	100
Helichrysum paralium	-	-	-	-	-	-	-	6	-
Lepidosperma gladiatum	-	-	-	-	-	-	-	12	-
Leucopogon parviflorus	-	-	-	-	-	-	-	6	-
Tetragonia implexicoma	-	-	-	-	-	-	-	6	-
Beyeria leschenaultii	-	-	-	-	-	-	-	6	-
Calocephalus brownii	-	-	-	-	4	-	-	6	-
Leptospermum laevigatum	-	-	-	-	17	-	-	19	-
Stipa stipoides	-	-	-	-	4	-	33	-	-
Apium insulare	-	-	-	-	-	-	17	-	-
Sarcocornia quinqueflora	-	-	-	-	-	-	17	-	-
No clear dominant	-	-	-	25	-	-	33	12	-
Pomaderris paniculosa	-	-	-	-	-	17	-	-	-
Poa poiformis	-	-	-	-	13	67	-	-	-
Myoporum insulare	-	-	-	-	9	-	-	6	-
Melaleuca ericifolia	-	-	-	25	4	17	-	-	-
Allocasuarina verticillata	-	-	33	25	35	-	-	12	-
Alyxia buxifolia	-	-	-	-	9	-	-	6	-
Kunzea ambigua	-	-	17	-	4	-	-	-	-
Leptospermum scoparium	33	40	50	-	-	-	-	-	-
Eucalyptus nitida	33	40	-	12	-	-	-	-	-
Callitris rhomboidea	-	20	-	12	-	-	-	-	-
Banksia marginata	33	-	-	-	-	-	-	-	-

9. *Poa poiformis* tussock grassland

Native shrubs: *Goodenia ovata*
Native grasses: *Poa poiformis*
Introduced grasses: *Aira caryophyllea*
Native graminoids: *Isolepis nodosa*
Native herbs: *Dichondra repens*
Introduced herbs: *Centaurium erythraea, Trifolium dubium*
This community usually consists of an open stratum of *P. poiformis* tussocks, interspersed with *I. nodosa,* and a low understorey dominated by a mixture of native and introduced herbs. It occurs on slightly acid to alkaline soils with a low cover of outcropping rock. Most of the area of this community has arisen from the activities of graziers and stock.

Ecological relationships

Both islands consist of an acid, coarse granite which is partly overlain by aeolian calcarenite, probably derived from the Bassian Plain during times of lower sea level than today. These two parent materials have resulted in the formation of soils of dramatically different pH, with a range from 4.5 to 9.5. Strong southerly to northwesterly winds bearing considerable quantities of salt spray appear to have interacted with parent material and vegetation to create weakly acid, red soils on parts of the lower granite slopes of the island, which contrast markedly with the highly acid, grey-black soils that are found on the higher peaks.

The role of soil conditions in differentiating the vegetation of the island is undoubtedly strong. Communities 1, 2, 4 and 9 are almost totally restricted to the calcarenite or calcareous sands, while communities 5-8 are restricted to the granite. There are many species that are restricted to one of the two substrata. For example, *Zygophyllum billardieri* and *Beyeria leschenaultii* are restricted to calcarenite, while *Aotus ericoides, Epacris impressa, Eucalyptus nitida* and *Lepidosperma concavum* are restricted to the granite. However, many other species have a wider edaphic range, with *Leptospermum laevigatum* and *Pultenaea daphnoides* occurring over the full range of pH.

Within both of the major geological types, there is a differentiation of the vegetation in response to exposure to salt spray. Community 2 occurs closest to the sea on the more exposed coasts, with community 3 occurring inland of it largely on granite, and community 4 occurring inland of it largely on calcarenite. The strong altitudinal break in community type may partly relate to exposure to salt spray, but is coincident with edaphic conditions, and may also relate to a precipitation gradient.

Apart from the obvious case of community 1, there is some evidence that soil drainage conditions may be important in differentiating the vegetation of the islands. The correlation of different types of heath with slope and soil characteristics provides circumstantial evidence of this phenomenon. Within the scrub and low forest communities, *Melaleuca ericifolia* tends to be most prominent in the valleys and on the gentler slopes, while *Allocasuarina verticillata* exhibits the opposite tendencies. However, this pattern may relate as much to tendency to drought or dryness as to the possibilities of impeded drainage.

Disturbance by burning and cattle-grazing appears to have had a strong influence on vegetation patterning, extending the range of tussock grassland at the expense of closed-scrub and low forest communities, and allowing and expediting the invasion of many exotic plants.

Conservation significance of the flora and vegetation

The flora of the two islands contains only one Tasmanian endemic species, *Eucalyptus nitida,* and no nationally rare or threatened species. However, it is rich in species that are rare in Tasmania. These species largely fall into two groups: those that are associated with offshore island coastal vegetation in high energy environments throughout southern Australia; those that are associated with highly calcareous soils.

Ixiolaena supina is one of the coastal species. It is also known from Rodondo, Curtis and Deal Islands in Tasmania and is classified as r1 by Kirkpatrick *et al.* (1991), this notation denoting that it has a distribution of less than 100 x 100 km in Tasmania. It is found in cracks on the granite cliffs near the seaward limit of vegetation on both islands and appears not to be threatened by grazing or other disturbance. *Apium insulare,* the other coastal rare species is classified as r2, denoting presence in less than twenty 10 x 10 km grid squares within Tasmania. It occurs in the moister granite cracks on the most salt spray-exposed clifftops of both islands. On Erith Island, it is only found in situations that are inaccessible to cattle.

The rare species associated with calcarenite are all classified as r2. *Pomaderris paniculosa* and *Beyeria leschenaultii* are found on calcarenite-covered clifftops on both islands, while the latter is also found on calcareous beach sand on Erith. Both species are regenerating in all the stands visited. *Zygophyllum billardieri* is a succulent creeper found on both islands, although it is more common on Erith. It was observed in areas that were both heavily used and unused by cattle. *Apalochlamys spectabilis* was only observed on Erith, where it acts as a disturbance coloniser in grazed open *Poa poiformis* grassland. *Parietaria debilis* was most common in the parts of the island with the highest exotic species cover, where it formed part of a closely grazed sward. *Leucopogon lanceolatus* was the only rare species to occur in the closed-scrub of the islands. It is classified as r2.

One of the most scientifically interesting aspects of the vegetation of the two islands is the species richness and composition of the heath that is found on the more elevated parts of Dover. With approximately 11 higher plant species per 10 x 10 m quadrat, this heath has very low species richness compared to similar heaths on the Tasmanian mainland and the largest Bass Strait islands. The most floristically similar communities recognised for Tasmania have species richnesses of non-geophytic plants that vary around 30 for the same quadrat size (Kirkpatrick 1977). With one major exception, *Callitris rhomboidea,* the species that occur in these heaths are a small subset of the common species in the heaths of the Tasmanian mainland and southern Victoria. Graminoids are noticeably uncommon, with only *Lepidosperma concavum* and *Baumea acuta* being noted. Given that this heath community is floristically distinct from all those recognised from Victoria (McMahon *et al.* 1990) and Tasmania (Kirkpatrick 1977, 1991), and is likely to be confined to the Kent Group, it must be considered an unreserved community. The other communities on the island have analogues reserved elsewhere in Tasmania, although the communities on calcarenite are poorly reserved.

A striking and unusual feature of the Dover heaths is the widespread presence of a native gymnosperm, *Callitris rhomboidea.* This species is easily eliminated by two successive fires in a few years (Harris & Kirkpatrick 1991). Its presence in the heaths and scrubs of the two islands reflects a continued wide spacing of fires since European occupance.

The vegetation and flora of the Kent Group as a whole have considerable biogeographic interest. The islands to the north have distinctly different scrub and forest vegetation, with *Melaleuca armillaris* replacing *M. ericifolia* on Curtis and Rodondo, and with *Eucalyptus globulus* ssp. *pseudoglobulus* being present on Rodondo instead of *E. nitida,* which reaches its northernmost limit in the Kent Group. Most of the islands of equivalent size to the south have been more severely degraded by grazing and fire than any in the Kent Group. None of them have the heath or eucalypt-dominated scrub found on Dover.

One interesting feature of the flora of the islands is the presence, in very low numbers, of two wet sclerophyll forest species, *Olearia viscosa* and *Pomaderris apetala.* These are found in coastal scrub on calcareous soils near the beach on Erith. *Olearia viscosa* was also found in closed-scrub on weakly acid soils on Dover. They may be the remnants of a more complex wet sclerophyll forest that could have occurred in the now submerged gorge between Deal and the two islands.

The low species richness of the inland communities compared to their larger island counterparts could relate to the chance extinctions that are predicted by island biogeography theory (MacArthur & Wilson 1967). This relaxation process has had at least the 6500 years since present sea levels were attained. It could also be the result of elimination of species because of lack of suitable migration paths, as climate changed and sea levels rose between 18 000 and 6500 years ago. A third explanation, which would be consistent with the lack of graminoids in the heath, could be a long period in which fire was absent, allowing the heath to become closed-scrub and, thereby, eliminating the habitat for heath species not also adapted to the salt-spray environment or existence on skeletal granite soils. This latter hypothesis is supported by the observation of Beth Gott (pers. comm.) that lightning strikes are much less common on Dover than on the adjacent Deal Island.

Given the above significant features of the vegetation and flora of the two islands, it would be desirable to make them, along with the remainder of the Kent Group, a Nature Reserve. The virtually untouched Dover Island has some of the highest claims in this regard of any of the unreserved Tasmanian islands. Care would need to be taken on Erith Island to ensure that the colonising rare species were not lost as shrub and tree reinvasion of the *Poa* grassland proceeded in the absence of stock and anthropogenic fire.

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FROM ICE TO ICE-FREE: GLACIATION IN THE LAKE AYR VALLEY, CENTRAL TASMANIA

by R.J.S. Wilson and D.G. Hannan

(with five text-figures)

Wilson, R.J.S. & Hannan, D.G., 1955 (30:vi): From ice to ice-free: Glaciation in the Lake Ayr Valley, central Tasmania. *Pap. Proc. R. Soc. Tasm.*, 129: 35–42. ISSN 0800–4703. IASOS, University of Tasmania, GPO Box 252C, Hobart, Tasmania, Australia 7001 (RJSW); Department of Physical Sciences, University of Tasmania, PO Box 1214, Launceston, Tasmania, Australia 7250 (DGH).

During the Last Glaciation in Tasmania a large ice cap developed on the western edge of the Central Plateau and overlapped on to the Cradle Mountain–Lake St Clair area. Several reticulate lobes flowed from this source, with the largest northern outlet, the Mersey Glacier, covering an area of c. 282 km^2.

The Lake Ayr Valley was occupied by a small diffluent lobe of the Mersey Glacier, and the lack of activity caused few erosional features to be formed. Moraines are abundant and can be related to the general retreat phase of the glacial system.

Evidence suggests that retreat was fairly rapid and no re-advance occurred during this period. Deglacial warming was well underway by 11 040 ± 280 yrs BP (SUA 3060).

Key Words: moraines, Last Glaciation, Lake Ayr Valley, Tasmania.

INTRODUCTION

The Lake Ayr Valley is situated west of the Tasmanian Central Plateau (fig. 1). It is a characteristic U-shaped glacial valley with altitudes of 850 m on the valley floor and over 1250 m on the edge of the Mount Oakleigh Plateau. The valley is located amongst some of the highest mountains in Tasmania, namely Mount Ossa (1617 m), Mount Pelion West (1554 m), Mount Pelion East (1400 m) and Mount Oakleigh (1280 m). Lake Ayr dominates the valley and drains to the west across Pelion Plains, discharging into the Forth River via Douglas Creek. Reedy Lake is a small lake at the eastern end of the valley, over the drainage divide from Lake Ayr, and drains eastwards into the Mersey Valley via Wurragara Creek (fig. 2).

The western part of the study area is underlain by Precambrian quartzite, mica schist and quartz mica schist, which form the basement rocks cropping out widely in the upper Forth Valley (Macleod *et al.* 1961). These rocks are overlain by post-Carboniferous, horizontally bedded sedimentary rocks, predominantly sandstone and mudstone, belonging to the Parmeener Supergroup (Burrett & Martin 1989, Macleod *et al.* 1961). This sequence has been extensively faulted and intruded by transgressive sheets of Jurassic dolerite that now cap the mountains in the area. Outcrop of the Parmeener Supergroup sediments is largely hidden by a cover of Quaternary till, fluvioglacials and solifluction sediments.

This paper presents the results of detailed mapping of glacial features in the Lake Ayr region and provides insight into the style and speed of glacial retreat at the end of the Last Glaciation.

PREVIOUS RESEARCH

There is a long history of observations of glacial action on the Central Plateau and the surrounding areas. Johnston (1893) was the first to suggest that the Central Plateau could contain an ice cap of sufficient volume capable of supplying "its western alpine valleys with numerous ice streams or glaciers". Reid (1919) surmised that ice from the Central Plateau would have spilled into the Mersey and Forth Valleys. Montgomery (1893) observed roches moutonnées west of Pelion Plains near the present footbridge over Douglas Creek.

Spry (1958) argued that the Mersey–Forth area was subject to both an ice cap and subsequent valley glaciation, and proposed that, during the ice-cap stage, the Forth Glacier reached at least to the present junction of Lemonthyme Creek and possibly as far as Lorinna (fig. 1). Jennings (1959) and Macleod *et al.* (1961), in detailed geological mapping of the area, recorded abundant glacial deposits in the Pelion Plains area on the interfluve between the Forth and Mersey Valleys.

Derbyshire *et al.* (1965) rationalised the glacial history of Tasmania and produced the first comprehensive glacial map of Tasmania. They identified moraines in the Lake Ayr Valley and proposed an ice limit at the western end of the valley. Paterson (1965, 1966) and Derbyshire & Peterson (1971) emphasised the importance of sediments in the reconstruction of the glacial history of the Central Plateau region and obtained the first certain evidence for multiple glaciation in the Mersey and Forth Valleys during the HEC construction work for the Mersey–Forth Power Scheme, when extensive drilling and site works exposed considerable glacial sediment.

Several authors have since established three glacial events in the Mersey Valley (Kiernan 1983, Hannan & Colhoun 1987, Hannan 1989). Kiernan & Hannan (1991) have provided reconnaissance data for the Lake Ayr region and established four episodes of glaciation in the Forth Valley.

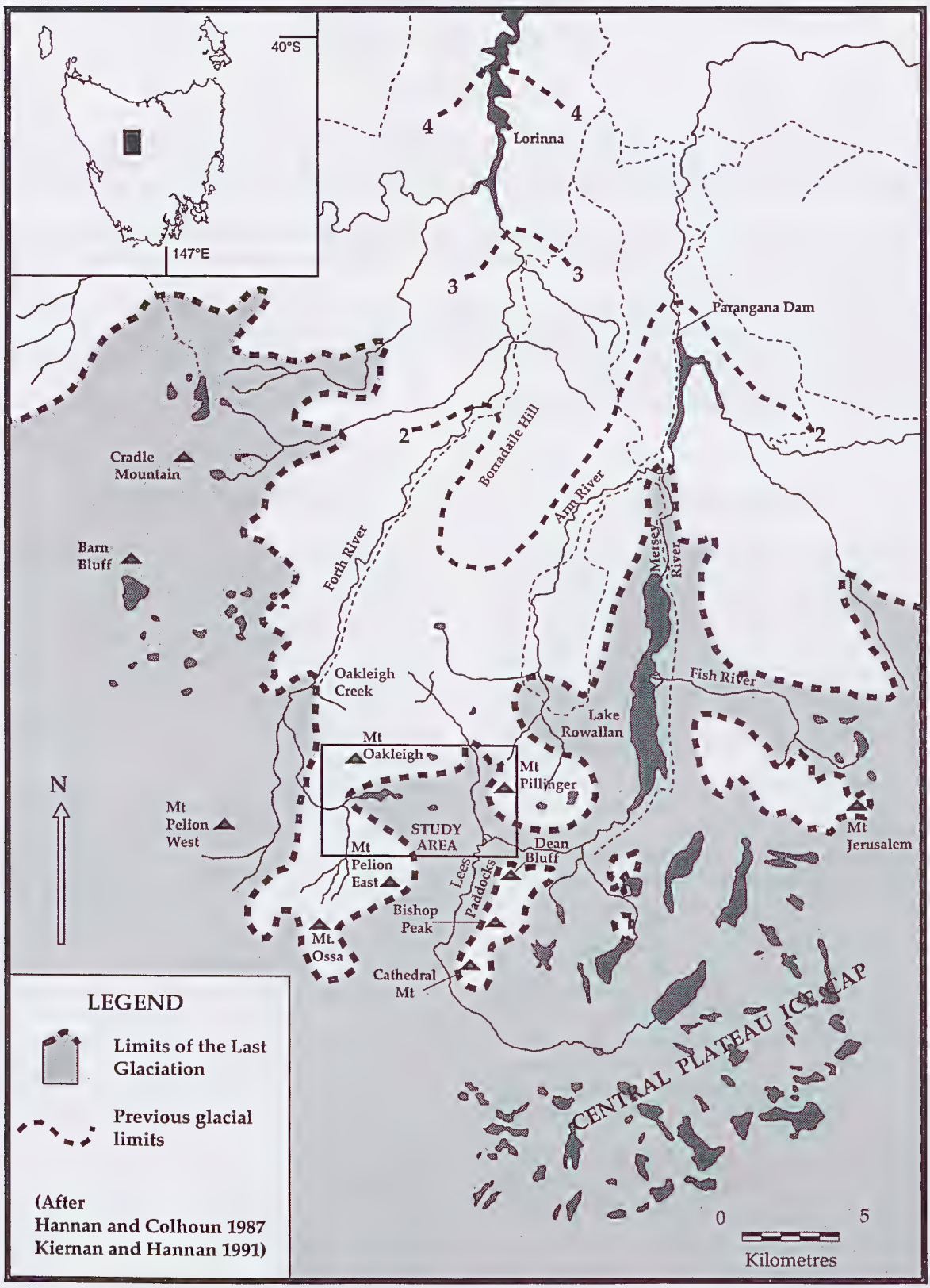

FIG. 1 — Locality map of the Mersey–Forth area and local glacial limits.

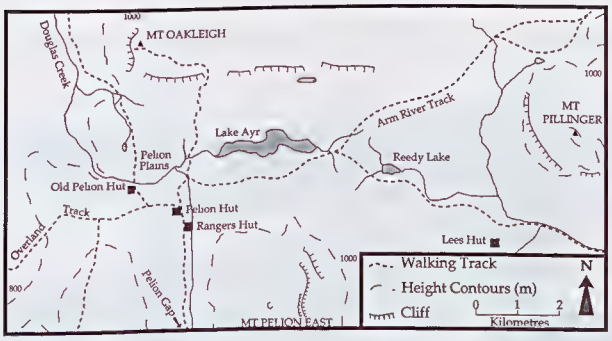

FIG. 2 — The Lake Ayr Valley.

THE LAST GLACIATION IN THE LAKE AYR VALLEY

Glacial Extent

During the Last Glaciation, the ice cap on the Central Plateau was the main source for the Mersey Glacier. Ice occupied about 282 km^2 of the Mersey Valley and filled the valley in the vicinity of Lees Paddocks to 1000 m, giving an ice thickness of greater than 400 m (fig. 1) (Hannan 1989). Evidence for this can be found in the creek between Bishop Peak and Dean Bluff, where till outcrops occur at 900 m, with the scree limit on the side of Dean Bluff between 1000 m and 1100 m (Hannan 1989) (fig. 1).

Across the valley, on the eastern flank of Mt Pelion East, an arcuate lateral moraine is visible at 1000 m altitude. This moraine can be traced northwards intermittently and eventually loops around as a latero-terminal moraine west of Lake Ayr. On this evidence, it can be deduced that the surface of the Mersey Glacier was at c. 1000 m, giving an ice thickness in the Lees Paddocks area of about 400 m. At the eastern end of the Lake Ayr Valley, ice would only have been about 160 m thick. Given that the westward gradient of the valley is small and that this ice did not penetrate through into the Forth glacial system but ended in a diffluent lobe, it is not surprising that erosional features are not in evidence from what would have been relatively inactive ice. This condition would have been ideal for the deposition of the large number of moraines found in the Lake Ayr Valley.

Glacial Depositional Features

Terminal, lateral and recessional moraines are observable in the area. These vary in height from a few metres to over 20 m (fig. 3), the largest being the latero-terminal moraines on the northern and southern sides of the valley. The increase in size of these moraines to the west suggests that the glacial system was at its maximum extent for a considerable period of time. In contrast, the large number of smaller recessional moraines suggest that there was rapid retreat once deglaciation commenced. The central portion of the terminal moraine is not present at the western end and, presumably, has been removed by meltwater erosion as the glacier retreated.

From the middle of the valley towards Mount Pelion East to the south, there are numerous prominent, arcuate moraine ridges, which appear to be arranged in steps. These are found to be replicated northwards towards the Oakleigh Plateau but, because of a steeper slope, are less obvious. On the southern side of the valley, they have the appearance of terraces on the edge of Mount Pelion East, and south of Reedy Lake detailed mapping revealed six levels, but more could be obscured in the dense vegetation.

The moraines in the valley are similar to other moraines in the Mersey Glacial system, in that they are smaller than others of similar age found elsewhere in the state (Hannan 1989). The West Coast Range moraines vary from 100–300 m, those in the Arthur Range are c. 100 m and in the Snowy Range c. 60 m in height (Colhoun 1985). This size difference occurs because the Lake Ayr glacial lobe was much less dynamic than the outlet glaciers from these other areas, with a corresponding reduction in erosion and, hence, transportation and deposition. The lack of dynamism has already been mentioned above but can be largely attributed to the fact that the lobe did not penetrate into the Forth System, due to lack of ice thickness above the valley step that separates the Mersey Valley from the Reedy Lake area. As a consequence, erosion was minimal in the flat-floored Lake Ayr Valley.

Glacial Erosional Features

It is likely that the Last Glaciation in this region did not radically change the landscape, and glaciers of this age probably followed pre-existing glaciated valleys. Very few erosional features associated with the Last Glaciation can be detected in the Lake Ayr Valley, because of the density of vegetation and extensive Quaternary sediment cover.

Meltwater channels are the most common glaciofluvial erosional feature of the area and can usually be observed alongside moraines, where deflection of pre-existing channels has occurred (e.g. Stockyard Creek – fig. 3). The outlet creek from Lake Ayr was formed in the retreat phase of the Last Glaciation and was originally fed by a proglacial lake. Extensive volumes of meltwater would have caused down-cutting by this creek through the moraines at the western end of the lake. Douglas Creek discharge would have been considerably higher in glacial times and, as a result, it cuts deeply into the quartzite bedrock west of Pelion Plains before draining into the Forth Valley. Figure 4 shows a schematic profile along the central axis of the Lake Ayr Valley, and west of Lake Ayr the valley floor rises before descending into the Forth Valley. This rise is due to the resistant quartzite/schist bedrock, as well as a mantling of morainic material, and indicates the extensive down-cutting achieved by Douglas Creek. This deep erosion into the bedrock is undoubtedly partly relict from older glaciations. Last Glacial age meltwater passed through this channel and, at the very least, incised through the morainic material upstream.

Dolerite erratics and quartzite roches moutonnées can be found west of Pelion Plains. These features are likely to be associated with the Penultimate Glaciation, as striations are not visible on the surfaces of the roches moutonnées. Presumably they have been removed by weathering. Weathering rinds on dolerite boulders in the surrounding ground moraine exceed 5 mm in average thickness, which suggests a Penultimate Glacial age.

The high mountains surrounding the area (Mount Pelion East, Mount Oakleigh, Mount Pillinger and Mount Ossa) were nunataks during the Last Glacial maximum. All were subjected to periglacial conditions for a significant period of time, and distinct evidence of this remains in the form of steep, mantling scree slopes.

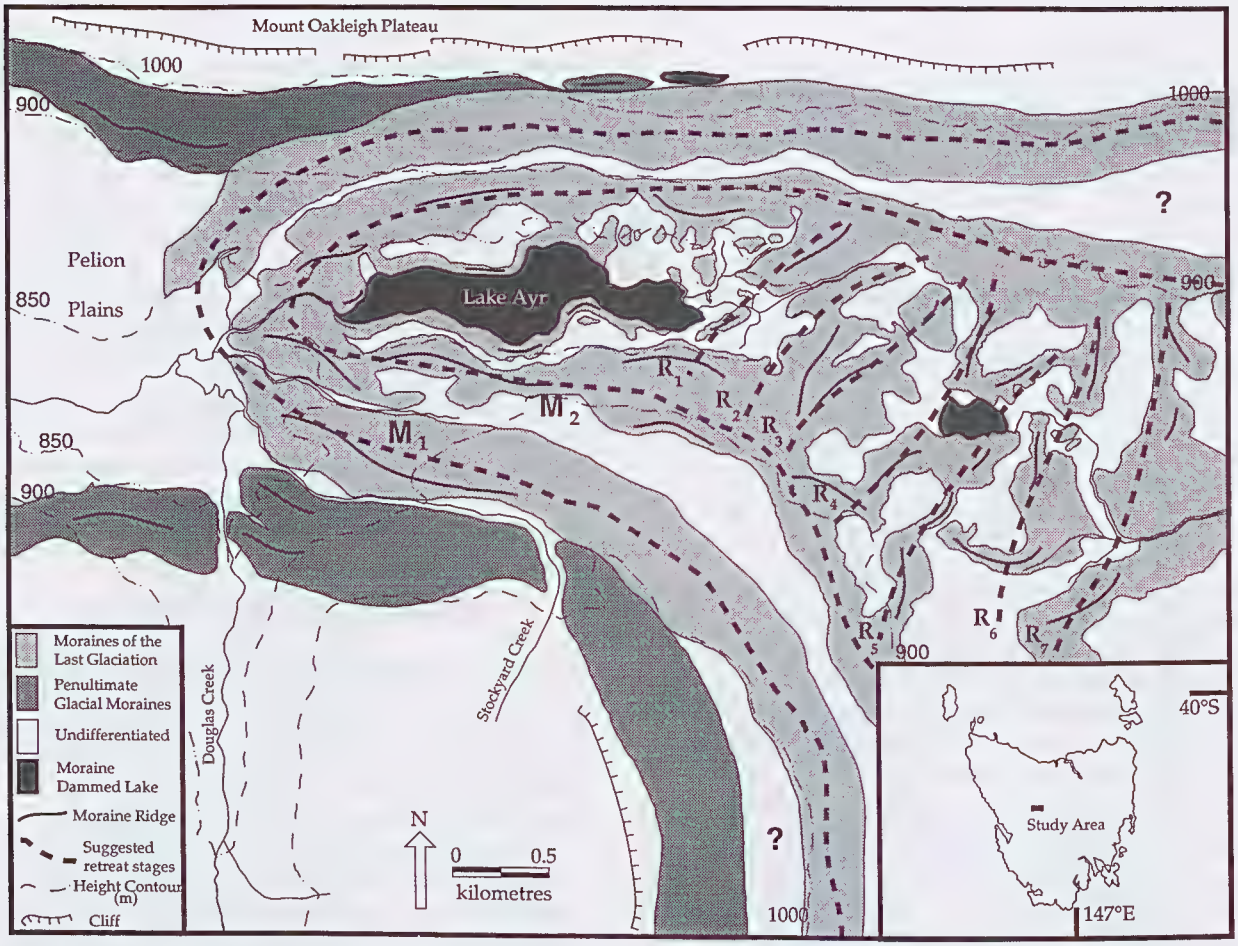

FIG. 3 — Latero-terminal moraines (M) and recessional moraines (R) in the Lake Ayr Valley. Suggested glacial retreat is indicated.

THE LAKE AYR VALLEY DURING THE LAST GLACIAL MAXIMUM

The maximum extent of Last Glaciation ice in the Lake Ayr Valley has ramifications in the ice budget of the Mersey Glacier. The main point to clarify is whether the ice flowed through the Lake Ayr Valley to join the Forth system. Field mapping has revealed five lines of evidence to show that ice from the Mersey Glacier did not reach the Forth Glacier at this time. These lines of evidence are as follows.

(1) Figure 3 shows the relationship of terminal, latero-terminal, lateral and recessional moraines in the Lake Ayr Valley. The latero-terminal moraine system clearly indicates the maximum extent of the Lake Ayr lobe during the Last Glaciation. An outwash plain commences immediately west of the terminal moraine and forms a part of Pelion Plains which is criss-crossed with relict meltwater channels. Sediment cores taken from the plains west of Lake Ayr, show a continuous peat cover of over 2 m on top of rhythmites (e.g. Core 6 – fig. 5) which would seem to suggest a proglacial zone.

(2) Lateral moraines of the Penultimate Glaciation are found on the valley edges above the highest latero-terminal moraines of the Last Glaciation. The penultimate moraines have relatively well-developed soil profiles, are incised more deeply by streams and have more rounded crests than the last glacial moraines. The clasts in the older moraines have weathering rinds from 1–6 mm with an average of 4.7 mm,

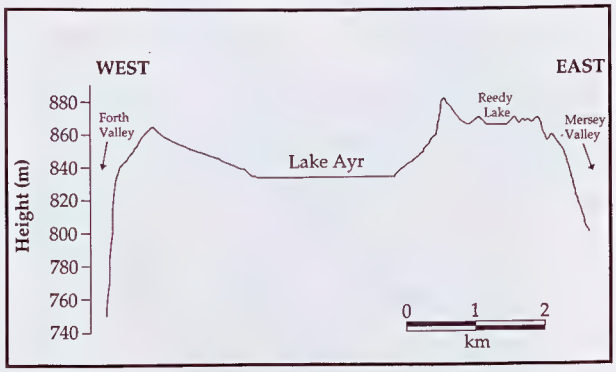

FIG. 4 — Schematic profile of the Lake Ayr Valley. Vertical scale is exaggerated 25 times.

whereas the last glacial moraines have dolerite weathering rinds averaging about 1 mm. The topographic location of Penultimate glacial moraines indicate that they were not overidden by last glacial ice.

(3) The soil profiles within the last glacial terminal moraine zone at the western end of Lake Ayr are not as well developed as the soil around the moraines of the Penultimate Glaciation. The soil visible around Lake Ayr is quite gravelly, lacking in organic horizons and is seldom weathered. Soils on the lateral moraines, high on the sides of the valley, are humified, weathered and have much deeper profiles than the soils on the valley floor.

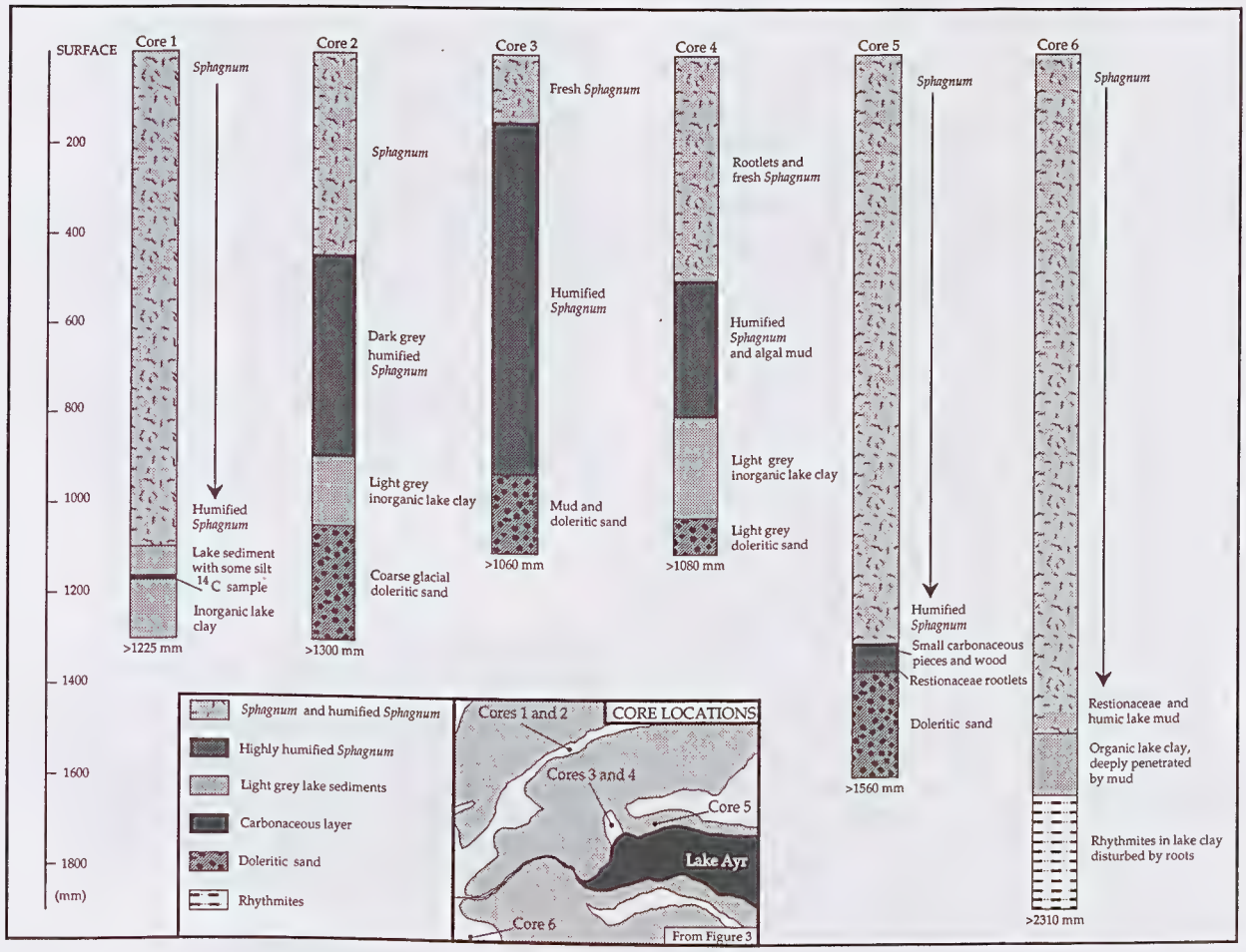

FIG. 5 — Sediment core stratigraphy and locations.

(4) Southwest of the summit of Mount Oakleigh (fig. 2), a small creek is crossed by the Forth Valley track (Grid Reference: 55GDP 198699). Along the creek there are extensive quartzite scree slopes on both sides of the valley. Their presence suggests that last glacial ice did not reach this point, as it would undoubtedly have removed the scree. The position of the creek is sufficiently low in altitude to have filled with last glacial ice had it flowed towards the Forth Valley. There is insufficient time for these thick screes to develop since the Last Glaciation because of the resistant nature of quartzite. They must have formed after the Penultimate Glacial maximum and beyond the maximum limits of last glacial ice. Similar dolerite screes can be found on the sides of the Mount Oakleigh Plateau and Mount Pelion East, above the main latero-terminal moraine of the last glacial lobe in the Lake Ayr Valley. Similarly, these are likely to have developed beyond the maximum limits of last glacial ice and temporally after the maximum of the Penultimate Glaciation.

(5) Further evidence which suggests that Last Glacial age ice did not flow into the Forth Valley via the Lake Ayr Valley is the difference in extent of the Forth and Mersey Glaciers during the Last and Penultimate Glaciations. During the Penultimate Glaciation, the maximum extent of the glacial ice in the Forth Valley is close to Borradaile Hill (fig. 1). During the Last Glaciation, the ice extent was 15 km upstream, close to Oakleigh Creek. In the Mersey Valley, during the Penultimate Glaciation, the maximum extended just below Parangana Dam (fig. 1), whilst in the Last Glaciation the maximum was 8 km upstream, close to the confluence of the Arm and Mersey Rivers. This indicates a Penultimate Glaciation of relative greater extent in the Forth Valley compared with the Mersey Valley.

The Forth Glacial System does not have a large catchment area (Kiernan & Hannan 1991). A likely reason for a more extensive maximum in the Forth Valley during the Penultimate Glaciation is ice loss from the Mersey System via the Lake Ayr Valley into the Forth system. In the Last Glaciation, ice terminated in the Lake Ayr Valley, and the Forth Valley Glacial System was undernourished and terminated some 15 km downstream, near the junction with Oakleigh Creek (fig. 1).

DEGLACIATION OF THE LAKE AYR VALLEY

Moraines are the most common glacial landform in the Lake Ayr Valley, and their shape, position and height allow speculation about the nature of the glacial retreat. Figure 3 shows suggested retreat stages in the Lake Ayr Valley. The main latero-terminal moraine (M1) is the highest moraine in the valley and suggests that the Lake Ayr glacial lobe maintained its maximum position for a reasonable period of time. The latero-terminal moraine (M_2) is the next highest

deposit and similarly indicates that the ice was located at this position for a considerable time. The moraine is, however, not as wide or high as M_1 and was deposited by a much reduced glacial lobe.

A radiocarbon date was obtained from a core taken from a moraine-dammed bog occurring between moraines M_1 and M_2 (Core 1 – fig. 5). The sample dated came from a depth of 1.1 m at an altitude of 860 m and consisted of a *Sphagnum* peat layer interbedded between inorganic lake clay. It gave an age of 11 040 ± 280 yrs BP (SUA 3060). The presence of Sphagnum in the intermorainal bog suggests a warmer period between colder conditions. Similar dates have been obtained in other locations in the area for the initiation of warmer conditions. At Dublin Bog Lobe in the Mersey Valley, at an altitude 590 m, the post-glacial temperature rise was underway by 13 400 ± 600 yrs BP (SUA 2188) (Hannan & Colhoun 1987, Colhoun *et al.* 1989). A small lobe in Wild Dog Creek near the Walls of Jerusalem, at an altitude of 1180 m, gave an age of 12 420 ± 150 yrs BP (SUA 3046) from algal mud. Given the occurrence of older dates in the region, the date of 11 040 ± 280 yrs BP may not define the time of ice retreat but it gives a minimum age for ice retreat from the Lake Ayr Valley.

The recessional moraines (R_1–R_7) are relatively close to each other and only a metre or two high. The regular nature of these moraines and their size suggests a fairly rapid and constant retreat. The low gradient of the valley and the limited ice thickness would have contributed to a rapid retreat, as a small decrease in ice volume in the main Mersey Glacier would have given a relatively larger reduction in the Lake Ayr ice volume. It is assumed that the moraine sequence from M_1 to R_7 becomes progressively younger, as there is no evidence to suggest any re-advance of the lobe.

Meltwater would have been considerable at the commencement of deglaciation and was responsible for the deep erosion into moraine M_2 and some of the incision of Douglas Creek into the quartzite/schist bedrock near Old Pelion Hut. In the later stages of deglaciation meltwater would have flowed towards the glacier and been responsible for the confused pattern of the moraines R_6 and R_7.

CONCLUSION

In the Mersey–Forth area, there is no clear local evidence which defines the onset of glaciation. In other parts of the state, this has been estimated at c. 25 000 yrs BP (Colhoun & van de Geer 1986). During the Last Glacial Maximum (c. 18 000 years ago) the Lake Ayr Valley was glaciated by a diffluent lobe of the Mersey Glacier. The Mersey glacial system, however, was not extensive enough for ice to penetrate through the Lake Ayr Valley to join the Forth Valley glacial system, as had occurred in earlier glacial episodes. Field work in the Lake Ayr Valley has revealed several lines of evidence to suggest that glacial ice during the Last Glaciation did not reach the Forth Valley. The most compelling evidence is the positioning of the moraines and the outwash plain, which were deposited by the glacial lobe. The lateral moraines in the Mersey Valley (at c. 1000 m a.s.l., Hannan 1989) have equi-valent moraines in the Lake Ayr Valley. These occur at the same height at the eastern end of the valley, but slowly decrease in height westwards until they meet the valley floor west of Lake Ayr (fig. 3). The central portion of the terminal moraine deposited at the snout of the glacier during the Last Glacial Maximum is absent, presumably because it was eroded by meltwater from the retreating glacier. The outwash plain forms part of Pelion Plains, and relict meltwater channels can be seen meandering across the plain before joining Douglas Creek.

From this study, the retreat of the glacial lobe in the Lake Ayr Valley has been dated to have been well underway before 11 040 ± 280 yrs BP (SUA 3060), which conforms with other parts of Tasmania. The moraines in the valley provide evidence of a glacial system that was at its maximum extent for a relatively long period of time. When glacial retreat commenced, it occurred at a steady rate. There is, however, no evidence to suggest re-advance at any time. It is considered generally that Tasmania was ice-free by about 10 000 yrs BP (Hannan 1989). A radiocarbon date from a cultural deposit in the upper Mersey Valley of 9760 ± 720 yrs BP (Beta 4757) indicates that the upper Mersey Valley was deglaciated by this time (Lourandos 1983).

ACKNOWLEDGEMENTS

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(accepted 10 October 1994)

THE VEGETATION AND FLORA OF DEAL ISLAND, KENT GROUP

by Stephen Harris and Georgina Davis

(with two text-figures and an appendix)

HARRIS, S. & DAVIS, G., 1995 (30:vi): The vegetation and flora of Deal Island, Kent Group. *Pap. Proc. R. Soc. Tasm.* 129: 43–51. ISSN 0800–4703. Parks and Wildlife Service, Department of Environment and Land Management, GPO Box 44A, Hobart, Tasmania, Australia 7001.

There are eight formations mapped for Deal Island comprising forests and woodlands, scrub, sedgeland, grassland and a coastal complex. Tussock grassland, which results from burning and clearing of *Allocasuarina* forest, occurs on the limestone soils, while the soils formed directly over granite are clothed with Eucalypt-dominated scrub and woodland with a heathy or shrubby understorey. A total of 176 plant taxa are recorded, of which only two are Tasmanian endemics. About one-quarter of the flora comprise exotic species. A distinct Bassian floristic element is present, which includes some Eremean flora.

Key Words: Bass Strait, vegetation, Tasmania, island biogeography, Deal, Kent

INTRODUCTION

Deal Island is the largest (1575 ha) of the Kent Group of islands situated in Eastern Bass Strait, midway between Flinders Island and Wilsons Promontory. It is a rugged granite island, with lenses of Tertiary limestone mantling the topographically more subdued areas on the northern and western parts. The highest point is about 395 m above sea level. The other islands comprising the group are Dover and Erith, which are joined to each other at low tide by a narrow isthmus, and the more outlying smaller islands of the group, North East and South West Islands.

Deal Island has been the site of a lightstation since 1843. North East and South West Islands are the sites of recently erected automatic lighthouses. Erith Island has been used for grazing for many years. The only permanent human habitation in the islands has been the continuous occupation of Deal Island by lightkeepers and their families.

Deal Island was formally transferred to the Commonwealth on 1 July 1915 and was gazetted a Wildlife Sanctuary on 28 July 1941, effective under the Tasmanian *National Parks and Wildlife Act 1970*. The island was nominated for the Register of the National Estate on 23 December 1976, and registered on 21 March 1978.

Botanical exploration of Deal Island has been sporadic and opportunistic, resulting in the publication of incomplete species lists and fragmentary accounts of the vegetation. Robert Brown made extensive botanical collections in 1803, especially of marine algae. Visits by parties from the Victorian Field Naturalists Club have made important contributions, but the first published list of Deal Island flora is that of Baron von Mueller (1885). The historical background to this collection has been discussed by Whinray (1993), who is known to have visited the island many times and published the results of his work (1971a, b). Hope & Hope (1968) attempted a synthesis of information about the island and made a preliminary description of the island's vegetation.

In contrast to the lack of any systematic account of the terrestrial flora, the marine flora and fauna around Deal Island have been systematically explored and more recently documented.

Baseline information on the composition and distribution of Tasmanian marine communities is meagre (Edgar 1984) but waters around the Kent Group have received some attention since the 1803 visit of Robert Brown (Le Souef 1891, Bennett & Pope 1960, King 1973, Last 1979, Kuiter 1981, Edgar 1984). Edgar recommended a marine reserve around the Kent Group on the basis of a very diverse marine fauna. He also noted the exceptional water clarity due to remoteness from any major source of runoff or pollution (Edgar 1984).

The Kent Group is located at the convergence of the three Southern Australian marine biogeographic provinces (Peronian, Maugean and Flindersian), resulting in a high faunal diversity. The number of seaweed species is not notably greater than elsewhere in the rich Bass Strait area. Edgar (1984) discussed the possibility of similar marine ecosystems occurring at Wilsons Promontory and around other islands, and concluded that the Kent Group was probably unique because of the diversity of habitats, different degrees of exposure, situation with respect to water currents, and absence of the influence of large estuaries.

Throughout the Quaternary, Bass Strait islands have, of course, alternated as islands and as high points on a broad Bassian plain. The peopling of the southeastern extremity of the continent, the patterns of movement of people across the landscape and the nature of vegetation changes and environmental fluctuations during the Quaternary and Holocene periods are issues of great interest to archaeologists and biogeographers (e.g. Bowdler 1984, Orchiston 1984, Jones 1969).

Accounts of the vegetation and flora of Bass Strait islands are few, especially given that there are just over 100 vegetated islands in eastern Bass Strait alone. Contributions to the biogeography of these islands are, therefore, a source of interest to a wide range of workers.

This paper is based on an unpublished report (Harris & Davis 1990) prepared for the Australian Heritage Commission by the present authors.

METHODS

Two weeks were spent on the island in May 1990. During this time the island was traversed, in order to sample the full range of vegetation types likely to be found on the island. Apparent vegetation boundaries were marked on a black and

white 1:40 000 aerial photograph dated 6 February 1982. As the photograph pre-dated the last fire, some modifications to the vegetation map were required. The pH of some soils was measured in the field by a CSIRO field pH test kit (Inoculo laboratories).

Three transect sketches were made with a tape, compass and clinometer on areas of sandy coast.

Human effects on islands can have a huge impact, so any study of island vegetation should examine the history of human contact. An examination of relevant historical sources was made to identify past impressions of Deal Island.

The visit was untimely for flowering, but specimens were collected of all species observed. Suitable specimens were lodged in the Tasmanian Herbarium.

A BRIEF HISTORY OF THE ISLAND

The Kent Group was discovered by Matthew Flinders in 1798, during a voyage to Preservation Island to rescue survivors of the *Sydney Cove* wreck. It was the investigations of Flinders, following the *Sydney Cove* episode, which led to the discovery of the numerous colonies of Australian Fur Seal. The exploitation of the seal populations in Bass Strait quickly followed.

In 1803, seven years before publication of his monumental *Prodromus Florae Novae Hollandiae ...*, the great British botanist Robert Brown landed on Deal Island and made extensive collections. As a result, the island is the type locality for many species of marine algae as well as terrestrial species such as *Myoporum insulare*.

Only four years before Robert Brown's landing, Lieutenant Flinders and Dr George Bass sailed past the Kent Group on their circumnavigation of Van Diemen's Land. In a contemporary account, Collins (1802) reports Bass' journal description:

> "This small group [of islands] appears to be formed of granite, which is imperfectly concealed by long straggling dwarfish brush, and some few still more diminutive trees, and seems cursed with a sterility that might safely bid defiance to Chinese industry itself. Nature is either working very slowly with those islands, or has altogether ceased work upon them, since a more wild deserted place is not easily to be met with. Even the birds seemed not to frequent them in their usual numbers."

Only a year before Robert Brown's landing, Captain Nicolas Baudin sailed past the Kent Islands, dismissing them with the comment, "None of the islands appeared to me to offer much in the way of resources for navigators" (Cornell 1974).

Some of the sealers settlements in Eastern Bass Strait were amongst the earliest European settlements outside Sydney Cove. For example, Kent Bay on Cape Barren Island was the site of a permanent sealers camp in 1798. When sealing commenced on Deal Island is uncertain but, since this island is more rugged and remote, it probably postdated the beginning of the slaughter in the Furneaux Group. It is not known how permanent the sealers camp at Garden Cove was. There is no apparent trace of it today. In 1831, George Augustus Robinson visited the camp and wrote in his journal (Plomley 1966):

> "Proceeded across the island for about two miles and came to the opposite coast where is a sandy beach and where the sealers have fixed their abode. The path across the hill is romantic, winding through some tea tree scrub. On reaching the huts we found the sealers had been gone for some time by the appearance of the huts. The sealers have several rude huts or hovels, which are built of bags tied with hay bands, and thatched with grass. The situation is in a valley and a stream of water runs through the settlement, but is very indifferent and of a sweet or aluminous taste. They have several gardens. Found some poultry; also some flour, potatoes and a musket in a hut. Found one whaleboat and two dinghies."

When Bass and Flinders proved the separation by sea of Van Diemen's Land from the New Holland main in 1798, they opened up the Strait as part of a major shipping route for sailing vessels from Europe travelling across the Indian Ocean, bound for Sydney Cove. Murray Pass and some of the Coves around Deal Island became important as anchorages during storms. The numerous rocks and islands, particularly in eastern Bass Strait, quickly began taking their toll of shipping, and the erection of lighthouses became an urgent need.

Murray-Smith (1980) noted that

> "the leading authority on Australian constitutional history of the period, Professor J. M. Ward, has pointed out in his work 'Earl Grey and the Australian Colonies' that the building of the Deal Island lighthouse was the first example of inter-colonial responsibility in the history of the movement towards the federation of those colonies and the evolution of the Australian Government today."

VEGETATION COMMUNITIES

Poa poiformis Tussock Grassland

This formation occupies about 305 ha, or 19.4% of the island and is generally confined to the areas of relatively more fertile and uniform soil cover. Such soils are more or less coincidental with the extent of limestone on flat to gently sloping areas.

The projective foliage cover of the dominant *Poa poiformis* varies but is commonly 100% on the areas more distant from the lightstation, out of range of domestic animal grazing.

Species occasionally emergent above, or codominant with *Poa poiformis* are bracken (*Pteridium esculentum*) and coastal sword sedge (*Lepidosperma gladiatum*). The intertussock flora most commonly comprises *Cirsium vulgare* seedlings, *Fumaria muralis, Hydrocotyle muscosa, Gnaphalium collinum, Oxalis perennans, Isolepis nodosus, Geranium* sp., *Senecio quadridentatus, Centaurium erythraea, Trifolium* sp., *Gonocarpus* sp., *Anagallis arvensis, Aira caryophyllea* and *Hypericum gramineum*. Following a time in 1987, thistles were very abundant (Max Lucas, Assistant Lightkeeper, pers. comm.), but the dense growth of the tussocks has effectively suppressed thistles in many areas.

The boundaries of the community are fairly sharp and coincide with higher soil fertility and fire boundaries, for example the boundary above Wintry Creek, near Winter Cove. The community mostly adjoins *Allocasuarina*

verticillata dominated formations and there appears to be active invasion of the grassland by *A. verticillata* in some places.

Stipa stipoides Tussock Grassland

This formation occupies about 0.6% of the island and is confined to a narrow strip around the more exposed areas of the coast, forming a zone exposed to salt spray. Soil type or fire frequency do not appear to be controlling factors in the distribution of this grass except in an indirect way. The most extensive area of *Stipa stipoides* tussock grassland is on the slopes above Little Squally Bay due south of the lightstation, where there is high exposure to the predominant storm weather direction and where protective tree and shrub cover has been eliminated.

The community is of open structure, with *Stipa* rarely exceeding 30% ground cover. Bare ground and rock are common. Associated plants are typical of rocky shore vegetation and include *Apium prostratum, Disphyma crassifolium, Calocaphalus brownii* (on unstable slopes) and *Cyathodes juniperina.*

Beach Dune Complex

Beaches are a minor mapping unit, comprising less than 1% of the coast, but they have distinct plant assemblages. The sand dunes occur at East Cove, Garden Cove and Winter Cove. All differ in degree of exposure, landform profile and plant species composition.

At Garden Cove the dunes are occupied by *Spinifex sericeus, Lepidosperma gladiatum, Isolepsis nodosus, Senecio lautus* and *Pteridium esculentum. Euphorbia paralius* and *Cakile maritima* occur on the shoreward of the dune (fig. 1A).

At Winter Cove, the beach is exposed to direct easterlies but is otherwise fairly protected. The beach system here comprises a wide berm occupied by *Spinifex sericeus* and *Isolepis nodosus.* At the southern extremity of the beach, the berm is colonised by a patch of *Ammophila arenaria.* A foredune and swale occur to the rear of the berm. The foredune is vegetated by *Lepidosperma gladiatum* and *Pteridium esculentum,* with occasional fire-killed shrubs of *Allocasuarina verticillata.* The swale is vegetated by *Dichondra repens, Parietaria debilis, Lepidosperma gladiatum, Pteridium esculentum* and *Poa poiformis* (fig. 1B).

At East Cove, the native vegetation is depleted because it has been displaced by exotics such as *Euphorbia paralius,* which forms a dense ground cover, and *Diplotaxis muralis* further up the slopes. *Atriplex prostata, Bromus diandrus* and *Zygophyllum billardieri* occur in the dune. On the weathered limestone, and even the limestone itself, behind the beach (above and below the track), *Threlkeldia diffusa* occurs as sometimes thick mats. *Allocasuarina verticillata* dominates the slopes immediately behind the beach (fig. 1C).

Cliff Complex and Steep Granite Slopes near the Coast

A high proportion of the coast is cliffed or at least comprises very steep granite slopes. The species occurring on the cliffs and slopes are often very similar to those on granite areas with skeletal soils, further inland, except in the more exposed sites where a typically coastal flora becomes dominant. The microtopographic variation gives rise to variable soil and moisture conditions which provide numerous different niches for plant species. There are rarely sections where an ordered zonation can be seen, but broadly there are three zones on exposed granite coasts in Bass Strait. The sequence is illustrated below:

sea — *Sarcocornia quinqueflora* zone — *Stipa stipoides* zone — *Poa poiformis* zone

Sarcocornia is occasional on lower parts of the shore, especially on gravel accumulations in sites subject to tidal influence. *Asplenium obtusatum* occurs in shaded places amidst large boulders in crevices. *Lobelia alata* is common in similar sites.

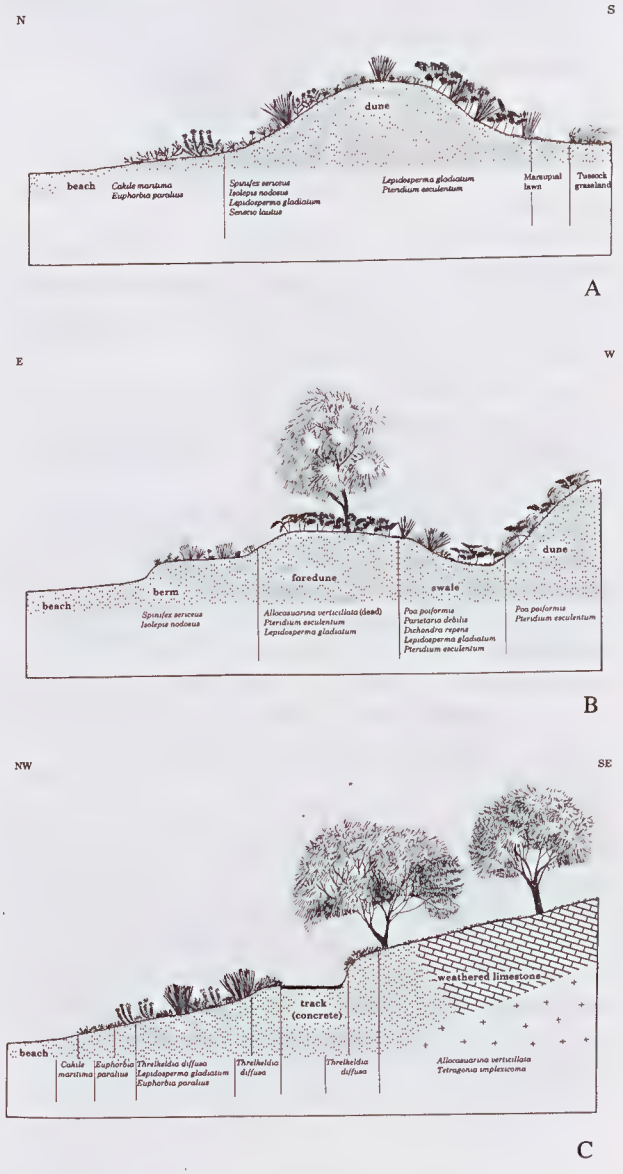

FIG. 1 — Vegetation profiles along three sandy coastal transects at (A) Garden Cove, (B) Winter Cove and (C) East Cove.

Stipa stipoides and *Isolepis nodosus* also grow in narrow crevices along with species such as *Crassula sieberana, Gnaphalium collinum, Plantago coronopus, Apium insulare* and *A. prostratum, Calandrinia calyptrata* and *Fumaria muralis. Stipa stipoides* commonly occurs with these species as well as with *Vellereophyton dealbatum* and *Carpobrotus rossii. Alyxia buxifolia, Olearia argophylla* and dwarf shrubs of *Leucopogon parviflorus* and *Leptospermum laevigatum* commonly occur in very exposed situations high on cliffs, in deep, wide fissures high on cliffs and on large boulder summits near the shore. Other species on the cliff summit between the Lighthouse and Little Squally Cove include *Stylidium graminifolium, Senecio lautus, Helichrysum paralium* and *Ixiolaena supina.*

The *Poa poiformis* zone contains fewer typically coastal species.

The rare *Ixiolaena supina* occurs typically in pendant mats on granite or arkose cliffs around the coast. At Little Squally Cove, the species occurs with *Crassula sieberana, Apium prostratum, Lobelia alata, Disphyma crassifolium* and *Stipa stipoides.*

In some areas on the most exposed sections of coast, where the granite is deeply weathered and breakdown products have formed steep unstable colluvial slopes, *Calocephalus brownii* is especially abundant.

Eucalyptus nitida Forests, Woodlands and Shrublands

Eucalyptus nitida formations occupy 47.5% (747 ha) of the island, mainly on the more rugged southern and eastern hills. Communities dominated by *E. nitida* are most common on the granite substrate, whereas *Allocasuarina verticillata* displaces *Eucalyptus* on limestone.

Eucalyptus nitida dominated communities are mapped as either forests or shrublands, but there is a complete gradation in height classes. Pockets of woodland were omitted for the sake of clarity in the map.

The *E. nitida* on Deal Island is commonly of mallee-form with pronounced coppicing. Based on the size of some mallee clumps, some lignotubers are up to 5–6 m in diameter. On deeper soils, particularly in areas that have escaped a high fire frequency, there are eucalypts with single main stems.

On flatter areas, where some soil or colluvium has been able to accumulate, there is usually a dense, shrubby understorey comprising species such as *Pultenaea daphnoides, Leptospermum laevigatum, L. scoparium, Acacia mucronata, Epacris impressa* and *Monotoca elliptica.* On the steeper granite slopes, ridges and hill tops, where there is only intermittent skeletal soil, the eucalypts are shorter and heavily coppiced. There is much more exposed bedrock, and the understorey is, therefore, more sparse. Common species include *Kunzea ambigua, Leptospermum laevigatum, Allocasuarina monilifera, L. scoparium, Pultenaea daphnoides* and *Goodenia ovata.* Species in this formation which are rare to the island include *Dodonaea viscosa* and *Schizea bifida. Crassula sieberana* is fairly common in narrow crevices in the granite.

Allocasuarina verticillata Forests and Woodlands

Allocasuarina verticillata low open woodland, low open forest and low closed forest together comprise 24.6% or 387 ha of the island, with low open woodland being the most common formation. Communities dominated by *A. verticillata* occupy limestone substrates on the northern part of the island. *Allocasuarina* formations occupy slopes around the granite coastline.

The *Allocasuarina* usually forms pure stands but occasionally shares the canopy with *Leptospermum laevigatum* and *Melaleuca ericifolia.* Associated species composition depends on proximity to onshore, salt-laden winds, geology, soil depth and moisture availability. On the limestone slopes at East Cove (fig. 2) where soils are shallow, alkalinity is high, and there is influence from the sea, *Leucopogon parviflorus, Leptospermum laevigatum* and *Helichrysum paralium* occur as a very sporadic shrub "layer". Although there is a great deal of bare ground, there are a number of low shrubs and herbs which include *Threlkeldia diffusa, Diplotaxis muralis, Tetragonia implexicoma, Dichondra repens, Lepidosperma gladiatum* and *Rhagodia candolleana.*

Above the head of the valley leading down to Garden Cove, a patch of *A. verticillata* woodland was burnt in the 1987 fire, leaving only a small unburnt patch. In the burnt area, apart from prolific regeneration of *A. verticillata,* the species recorded included *Pomaderris paniculosa* ssp. *paralia, Clematis microphylla, Gyrostemon thesioides, Swainsonia lessertifolia, Dampiera stricta, Gnaphalium collinum, Pseudognaphalium luteo-album* and *Danthonia racemosa.* In this area, the friable loamy soil had a measured pH of 8.

A. verticillata occurs as low closed forest in some areas, especially on the steep slopes below the cliffs, west of the lighthouse. *Callitris rhomboidea* is an occasional component of this formation.

Lepidosperma gladiatum Sedgeland

This formation occupies only about 5 ha, which is about 0.3% of the island. The species occurs on the beach systems described above and sometimes forms locally dense patches on some of the dune systems.

At the eastern end of Squally Bay, there is a slope of limestone, which is dominated by *Lepidosperma gladiatum* in association with *Poa poiformis, Pteridium esculentum* and *Carex apressa. Callitris rhomboidea,* less than 1 m in height and severely wind pruned, occurs patchily, especially on the slope immediately west of Ferny Spring Gully at the eastern head of Squally Cove.

Myoporum insulare Scrub Open and Closed

This formation is the smallest mappable vegetation type, occupying no more than 1.5 ha south of East Cove. It is described here because it is so distinctive, and also because both the species and the vegetation type may have been more widespread on the island in the past.

The stand occurs on a moderate slope with north to northwest aspect, close to the shore. The substrate is calcareous sand with limestone cobbles occupying 95% of the

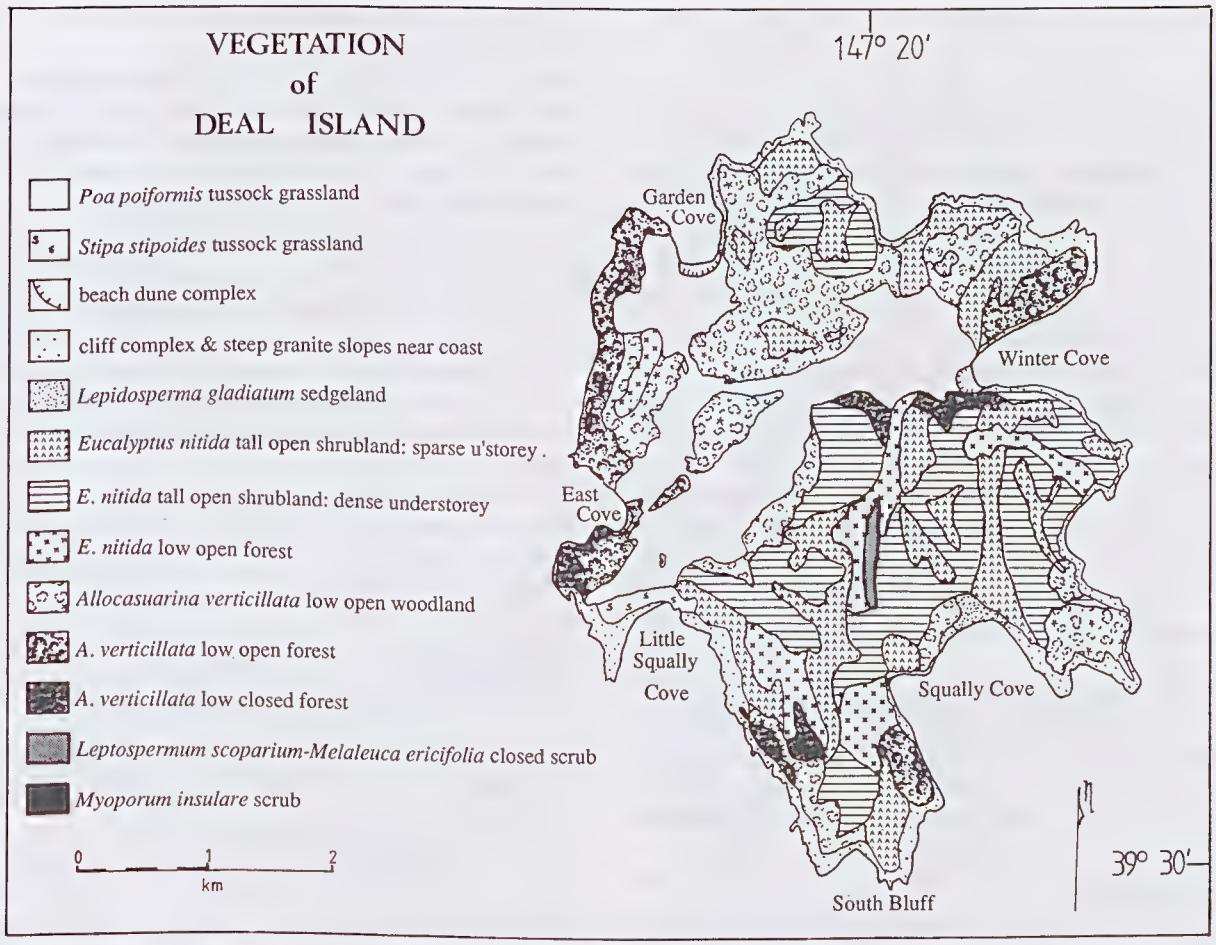

FIG. 2 — Vegetation of Deal Island.

surface. Most of the soil is completely bare. There are a small number of granite boulders strewn about, derived from upslope weathering. The *Myoporum* trees occur in a very shallow, broad depression running uphill from the shore.

The community is very species poor, which must be largely due to the low light levels under the canopy of the closed scrub. *Threlkeldia diffusa* appeared to be struggling for survival under the canopy, and only *Rhagodia candolleana* and *Poa poiformis* occur in the patches where there is more light. On the edges of the *Myoporum scrub, Tetragonia implexicoma* forms dense climbing mats over shrubs and fallen trees.

Leptospermum scoparium–Melaleuca ericifolia Closed Scrub

The only notable patch occupies about 6 ha or about 0.4% of the island. There are small discontinuous patches on Little Squally Creek which escaped the 1987 fire. Small patches also occur on the middle reaches of Garden Cove Creek. The largest patch occurs in an elevated, broad, shallow gully in the central southeast of the island, at the headwaters of Winter Cove Creek.

This large patch occurs on black, peaty soil overlying siliceous colluvial gravel derived from the weathering of adjacent granite hills. This colluvium may be fairly deep, which would act as a large "sponge", enabling slow release of groundwater into one of the only three reliable creeks on the island.

The largest patch comprises *Melaleuca ericifolia, Leptospermum scoparium* and *Callitris rhomboidea* between about 3 and 3.5 m height. There is occasional emergent *Eucalyptus nitida,* while the understorey is mostly leaf litter with partial moss cover and some bare ground. The small patches on Little Squally Creek and Garden Cove Creek are dominated by *M. ericifolia.*

ANALYSIS OF THE FLORA

There were 176 vascular plant taxa from 63 families recorded from the island in May 1990 and on a very brief subsequent trip in December 1990. Our list contains 44 exotic species, 12 of which are grasses. The number of exotics recorded, therefore, comprises about one-quarter of the flora, but this proportion could be expected to increase if a more thorough collection was made in the pasture and garden areas around the lightstation.

The "complete census" of the island flora was compiled by Baron Von Mueller in 1884 from specimens collected by the lighthouse keeper. He recorded *Eucalyptus obliqua* but none can be found today on the island. *E. nitida* is widespread, yet no other eucalypt appears on Von Mueller's list. This suggests that *E. nitida* may have been mistaken for *E. obliqua,* possibly on the basis of an incomplete

specimen, as we previously suggested (Harris & Davis 1990). The possibility of misidentification is also supported by Whinray (1993).

Von Mueller again identified a list of plant species collected from the Kent Group by the expedition of the Field Naturalists Club of Victoria (Le Souef 1891). There were 84 species (excluding exotics) recorded, but there is no indication of which of the islands the species are from. *Goodia lotifolia* has also been identified, but *Phyllanthus gunnii*, to which it bears a superficial resemblance and which is very common on parts of the island, was not listed. We did not see *G. lotifolia*. Von Mueller draws particular attention to several species as being noteworthy. One is *Didymotheca thesioides* (*Gryostemon thesioides*). This species was recorded by us as common in patches on the island but appears uncommon to rare elsewhere in Tasmania. Von Mueller (Le Souef 1891) implies that the species is uncommon on mainland Australia, and Willis (1972) does not list the species for Victoria. Other noteworthy species are those classified as rare in Tasmania (Flora Advisory Committee 1994): *Lepidium pseudotasmanicum, Apium insulare, Apalochlamys spectabilis, Gyrostemon thesioides, Ixiolaena supina, Parietaria debilis, Pomaderris paniculosa* ssp. *paralia, Zygophyllum billardieri* and *Centrolepis pulvinata*. Gullen *et al.* (1990) list *Asplenium obtusatum* as vulnerable in Victoria. However, it is frequent and secure in shaded crevices and overhangs around the rocky coasts of Tasmania and has been recorded from many locations in the Furneaux group.

Pratia irrigua R.Br. was collected from a *Carex apressa–Gahnia* sedgeland on a slope above Little Squally Creek, in the damp ground associated with a spring seeping out from under the limestone cap on the granite. Previously taken to be endemic to the island, the species is now considered to be within the morphological range of *P. platycalyx* (Albrecht 1992).

A plant list compiled by G.K. Thompson (source of data unspecified) is given in Hope & Hope (1968). This lists 64 species of vascular plants specifically for Deal Island but again *Goodia lotifolia* is listed and not *Phyllanthus gunnii*. *Eucalyptus obliqua* is also listed for the island in addition to *E. amygdalina* (*E. nitida*). A further 36 species are listed as general records for the Kent Group.

Whinray (1971b) lists 76 species of vascular plants from Deal Island which at the time were new to the island. Of these, 44 were exotics.

It is hoped that publication of the present species list for the island will stimulate botanical visitors to the island to add further records. We believe an annotated checklist of flora of the Kent Group is needed which would include records scattered in various herbaria.

DISCUSSION

Deal Island is in many ways typical of islands in eastern Bass Strait in terms of vegetation. The major formations dominated by *Poa* tussock and *Allocasuarina* are common. *Eucalyptus nitida* communities are common on Flinders Island. The plant species list recorded on Deal Island is also very similar to that of other islands in the Furneaux Group (S. Harris and A. Buchanan, unpubl. data). As with the other Furneaux Islands, the vegetation patterns reflect the same influence by humans. The dominant influences on vegetation patterning are salt spray, fire, human activity and soil fertility (limestone versus granite).

Exposure to salt spray imposes a major dichotomy in patterning of plant communities which generally overrides geology type (Harris & Kirkpatrick, 1982) and is a general feature of islands. The typically coastal vegetation is distinguished by salt/drought adapted herbs and shrubs in the genera Chenopodiaceae and Aizoaceae. The most salt-tolerant zones can expand inland, as a result of burning or clearing into the scrub or woodland behind the usually narrow *Stipa stipoides* zone. If a wooded island is repeatedly burnt, it will convert to tussock grassland, where soils are reasonably fertile, and the greater exposure will result in greater input of salt to the ground, therefore favouring the more salt-tolerant vegetation usually found only in a narrow band.

Fire has had a dominating influence on present vegetation patterns in the islands. Islands have often been burnt to extend and maintain the tussock at the expense of woodland and forest communities. This has been the case on Deal Island, where Garreau (1958) commented that

> "Very numerous is the Dropping Sheoke (*Casuarina stricta*) but this lovely old tree is slowly losing ground due to the annual burning off killing young ones."

Away from the coast, soil fertility is a major factor in determining vegetation patterning. There are two lithological types of the island — granite and limestone. The granite dictates the rugged nature of the island and forms very uneven topography. Soils are of variable depth but are mainly skeletal and acid, and the major plant communities which occur are *Eucalyptus nitida* forests, woodlands and shrubland.

The limestone occurs as a thin veneer on the island and remains on the area of more even topography. The area covered by *Poa* tussock broadly coincides with the area of limestone. The soils on the limestone are alkaline and shallow. There are some areas at the surface forming broken rocky ground. This kind of substrate generally has retained *Allocasuarina* forest or woodland. Eucalypts are generally not tolerant of high pH soils (Pryor 1976), therefore most of the area occupied by *Poa* tussock grassland was probably occupied formerly by *Allocasuarina* forest.

The search for a distinctive discontinuity in Bass Strait, between the Tasmanian and mainland floras would result in disappointment. The boundary between Tasmanian and mainland fauna is much more distinct, and Deal Island is close to that boundary (Hope 1972).

There is a more complicated pattern for flora distribution, with the most interesting aspect being the existence of a dry southern Australian and eremean component of the flora, reaching its southernmost extension in the relatively more reliable rainfall areas of eastern Bass Strait. This paradox is only apparent because the abundance of Tertiary limestone throughout the Furneaux Group and Kent Group provides a substrate which requires a drought tolerant flora, especially as high salt concentrations in onshore winds exacerbate drought conditions. Examples of species and genera which represent this group include *Threlkeldia diffusa, Ixiolaena, Zygophyllum, Gyrostemon* and (in the Furneaux Group) *Frankenia* and *Sicyos*.

A distinct Bassian floristic element is also represented throughout the Bass Strait islands and the limestone coasts of southern Victoria, Kangaroo Island and the southern

part of the Eyre Peninsula. This element is represented on Deal Island by species such as *Apium insulare, Ixiolaena supina, Pomaderris paniculolsa* ssp. *paralia* and *Swainsona lessertifolia.* Taxa near the limits of their distributions, occurring on Deal Island, include *Sarcocornia quinqueflora* ssp. *tasmanica, Posidonia australis, Eucalyptus nitida* and *Centrolepis pulvinata. Asplenium obtusatum* is listed by Gullen *et al.* (1990) as vulnerable in Victoria.

The number of exotic species on the island is much higher than on islands such as Rodondo or Dover Island, but most other islands of comparable size in eastern Bass Strait have a very high exotic species component, reflecting the long history of European activity in these islands.

Species invasion is still occurring on the coasts. A small patch of *Ammophila arenaria* occurs on the beach at Winter Cove. *Euphorbia paralius* is a recent invader of sandy beaches on southern Bass Strait coasts. The species was first noted in 1988, as only a few plants at East Cove, on Deal Island, by the wife of the Head Lightkeeper (Shirley Gray, pers. comm.). Shortly afterwards it expanded into what is now a dense infestation on the foredune.

Inventory of the flora on the islands scattered through Bass Strait and an understanding of their ecology and vegetation history provide information which is crucial to nature conservation planning and management, as well as useful data for archaeologists, biogeographers and others. It is hoped that this paper contributes to these aims.

ACKNOWLEDGEMENTS

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(accepted 13 December 1994)

APPENDIX I

List of vascular plants recorded from Deal Island, May 1990. Many of the collected specimens have been lodged in the Tasmanian Herbarium (HO). Species nomenclature follows Buchanan *et al.* (1989). (I) following species name = introduced taxa; (E) = taxa endemic to Tasmania and offshore islands.

DICOTYLEDONS

AIZOACEAE
- *Carpobrotus rossii*
- *Disphyma crassifolium*
- *Tetragonia implexicoma*

APIACEAE
- *Apium insulare*
- *A. prostratum*
- *Hydrocotyle muscosa*
- *Lilaeopsis polyantha*

APOCYNACEAE
- *Alyxia buxifolia*

ASTERACEAE
- *Actites megalocarpa*
- *Apalochlamys spectabilis*
- *Arctotheca calendula* (I)
- *Brachyscome diversifolium*
- *Calocephalus brownii*
- *Cirsium vulgare* (I)
- *Cotula coronopifolia*
- *Gnaphalium collinum*
- *Helichrysum apiculatum*
- *H. paralium*
- *Hypochoeris radicata* (I)
- *Ixiolaena supina*
- *Olearia phlogopappa* var. *phlogopappa*
- *Pseudognaphalium luteo-album*
- *Senecio jacobaea* (I)
- *S. lautus*
- *S. linearifolius*
- *S. minimus*
- *S. quadridentatus*
- *S. vulgaris* (I)
- *Sonchus oleraceus* (I)
- *Vellereophyton dealbatum*

BRASSICACEAE
- *Cakile maritima* (I)
- *Diplotaxis muralis* (I)
- *Lepidium pseudotasmanicum*
- *Rorippa nasturtiumaquaticum* (I)

CAMPANULACEAE
- *Lobelia alata*
- *Pratia platycalyx*
- *Wahlenbergia gracilenta*

CAPRIFOLIACEAE
- *Sambucus gaudichaudiana*

CARYOPHYLLACEAE
- *Sagina apetala* (I)
- *S. maritima* (I)
- *Stellaria pungens*

CHENOPODIACEAE
- *Atriplex prostata*
- *Chenopodium glaucum*
- *Chenopodium pumilio*
- *Rhagodia candolleana*
- *Sarcocornia quinqueflora* ssp. *tasmanica*
- *Threlkeldia diffusa*

CLUSIACEAE
- *Hypericum gramineum*

CONVOLVULACEAE
- *Dichondra repens*

CRASSULACEAE
- *Crassula sieberana*

CASUARINACEAE
- *Allocasuarina monilifera*
- *A. verticillata*

DROSERACEAE
- *Drosera pygmaea*

EPACRIDACEAE
- *Cyathodes juniperina*
- *Epacris impressa*
- *Leucopogon parviflorus*
- *Monotoca elliptica*

EUPHORBIACEAE
- *Euphorbia paralius* (I)
- *E. peplus* (I)
- *Phyllanthus gunnii*

FABACEAE
- *Acacia melanoxylon*
- *A. mucronata*
- *A. verticillata*
- *Albizia lophantha* (I)
- *Melilotus ?alba* (I)
- *M. indica* (I)
- *Pultenaea daphnoides* var. *obcordata*
- *Swainsona lessertifolia*
- *Trifolium dubium* (I)
- *T. subterraneum* (I)
- *T. tomentosum* (I)
- *Vicia sativa* (I)

FUMARIACEAE
- *Fumaria muralis* (I)

GENTIANACEA
- *Centaurium erythraea* (I)

GERANIACEAE
- *Erodium cicutarium* (I)
- *Geranium* sp.
- *Pelargonium* sp.

GOODENIACEAE
- *Dampiera stricta*
- *Goodenia ovata*

GYROSTEMONACEAE
- *Gyrostemon thesioides*

HALORAGACEAE
- *Gonocarpus teucrioides*
- *Myriophyllum salsugineum*

LAMIACEAE
- *Marrubium vulgare* (I)

MYOPORACEAE
- *Myoporum insulare*

MYRTACEAE
- *Calytrix tetragona*
- *Eucalyptus nitida* (E)
- *Kunzea ambigua*
- *Leptospermum laevigatum*
- *L. scoparium* var. *eximium*
- *L. scoparium* var. *scoparium*
- *Melaleuca ericifolia*

ONAGRACEAE
Epilobium billardierianum
OXALIDACEAE
Oxalis perennans
PITTOSPORACEAE
Bursaria spinosa
PLANTAGINACEAE
Plantago coronopus (I)
POLYGONACEAE
Rumex acetosella (I)
PORTULACEAE
Calandrinia calyptrata
PRIMULACEAE
Anagallis arvensis (I)
PROTEACEAE
Banksia marginata
RANUNCULACEAE
Clematis microphylla
Ranunculus sp.
RHAMNACEAE
Pomaderris aspera
P. paniculosa ssp. *paralia*
RUBIACEAE
Galium australe
Opercularia varia
Sherardia arvensis (I)
RUTACEAE
Correa alba
C. ?backhousiana
Ziera arborescens
SAPINDACEAE
Dodonaea viscosa
SCROPHULARIACEAE
Verbascum thapsus (I)
SOLANACEAE
Solanum laciniatum
S. nigrum (I)
STACKHOUSIACEAE
Stackhousia monogyna
STYLIDIACEAE
Stylidium graminifolium
THYMELAEACEAE
Pimelea linifolia
URTICACEAE
Parietaria debilis
Urtica incisa
ZYGOPHYLLACEAE
Zygophyllum billardieri

GYMNOSPERMS
CUPRESSACEAE
Callitris rhomboidea

PTERIDOPHYTES
ASPLENIACEAE
Asplenium obtusatum
BLECHNACEAE
Blechnum nudum
CYATHEACEAE
Cyathea australis
DENNSTAEDTIACEAE
Histiopteris incisa
Hypolepis rugosula
Pteridium esculentum
Pteris tremula
DICKSONIACEAE
Dicksonia antarctica
SCHIZAEACEAE
Schizaea bifida
SINOPTERIDACEAE
Pellaea falcata

MONOCOTYLEDONS
ARACEAE
Zantedeschia aethiopica (I)
CENTROLEPIDACEAE
Centrolepis fascicularis
C. pulvinata (E)
C. strigosa
CYPERACEAE
Baumea acuta
B. juncea
Carex appressa
Carex sp.
Gahnia filum
G. trifida
I. auklandica
I. cernua
I. inundatus
I. nodosus
L. concavum
L. gladiatum
Schoenus nitens
IRIDACEAE
Iris sp. (I)
JUNCACEAE
Juncus bufonus
J. krausii
J. pallidus
J. pauciflorus
Luzula flaccida
JUNCAGINACEAE
Triglochin striata
ORCHIDACEAE
Pterostylis longifolia
POACEAE
Agrostis avenaceae
Aira caryophyllea (I)
Ammophila arenaria (I)
Anthoxanthum odoratum (I)
Briza minor (I)
Bromus diandrus (I)
Catapodium rigidum (I)
Cynosurus echinatus (I)
Danthonia caespitosa
D. racemosa
Holcus lanatus (I)
Pennisetum clandestinum (I)
Poa annua (I)
P. labillardieri
P. poiformis
Polypogon maritimus (I)
P. monspeliensis (I)
Spinifex sericeus
Stipa flavescens
S. stipoides
TYPHACEAE
Typha orientalis

WEATHERING AND MORPHOSTRATIGRAPHIC EVIDENCE FOR FOUR GLACIATIONS IN THE HENTY RIVER BASIN, WESTERN TASMANIA

by Paul C. Augustinus and Eric A. Colhoun

(with two tables and three text-figures)

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The Quaternary glacial histories of the Pieman and Henty River Basins have largely been developed by using post-depositional weathering criteria to identify and map the drift sheets. Application of relative dating techniques, such as percentage absorption and specific gravity of Cambrian volcanic clasts, forces a reinterpretation of palaeomagnetic evidence previously offered for the age of the Henty Drift, so that at least three pre-Last Glacial Maximum (LGM) drift sheets can be recognised. The deeply weathered and most extensive (but with limited exposure) Berry Creek Drift is possibly a correlative of the Bulgobac/Linda Drift and can be clearly distinguished from the slightly less extensive but more widely exposed Henty Drift. A minimally weathered and spatially restricted drift, termed the Julia Drift, is exposed beyond and pre-dates the LGM end moraines.

Keywords: glaciation, Henty Basin, relative dating, correlation, drift sheets, Tasmania.

INTRODUCTION

The Late Cenozoic glacial history of western Tasmania has been reviewed in a number of studies (Colhoun 1985a, Colhoun & Fitzsimons 1990, Kiernan 1990a, Fitzsimons *et al.* 1993). Although the essential elements of glacial histories of each major drainage basin have been elucidated (Pieman Basin – Augustinus & Colhoun 1986, Augustinus *et al.*, 1994; Henty Basin – Colhoun, 1985a,b; the King Basin – Fitzsimons & Colhoun 1991, Fitzsimons *et al.* 1993), the timing of the identified glacial events from each basin is poorly constrained, due to the general absence of datable material. As a consequence of this uncertainty, correlations between glacial sequences, even from adjacent valleys are problematical.

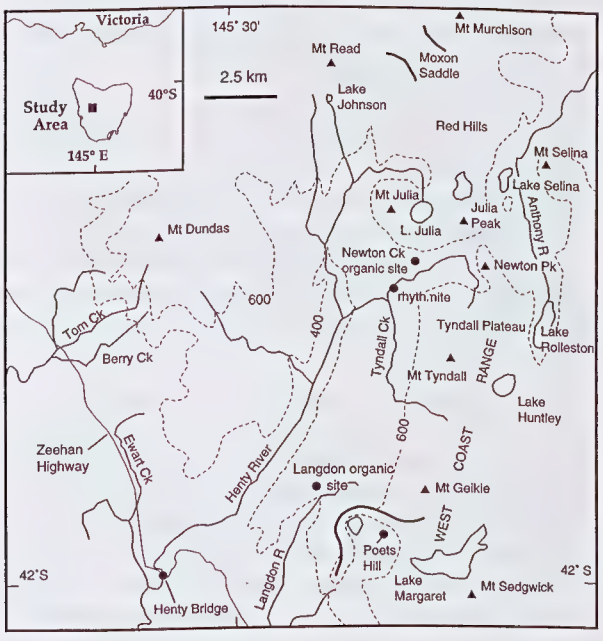

FIG. 1—Location map, Henty River Basin

Correlations between the sequences from each of the basins have necessarily been made on the basis of post-depositional weathering criteria, such as thickness of weathering rinds developed on clasts of Jurassic dolerite, and relative degrees of till matrix alteration and soil development. Use of these relative dating (RD) techniques enabled the discrimination of the sediments deposited by different glacial events. However, use of RD criteria (such weathering rind thickness variations) for correlation of glacial sequences between even adjacent drainage basins is hampered by the general absence of dolerite in the glacial sediments from some valleys. In addition, climatic and topographic drainage differences pertaining between basins influence the rate of weathering and, hence, the validity of correlations made on the basis of such criteria (Kiernan 1990b).

This paper assesses the use of several post-depositional weathering criteria in mapping the glacial drifts of the Henty River Basin (fig. 1) and attempts to correlate the drift sheets defined with those mapped in the adjacent Pieman Basin. Since Jurassic dolerite is absent from most of the Henty Basin Drifts, alternative RD criteria had to be used, including percentage absorption and specific gravity variations in Cambrian volcanic clasts from glacial diamictons. We combine the RD information with palaeomagnetic evidence to construct a correlation of the glacial sequences between the basins that is more reliable than any hitherto.

GLACIAL HISTORY OF THE HENTY RIVER BASIN

The glacial history of the Henty Basin was first studied by Bowden (1974), and glacial landforms were mapped as the product of one glaciation. The first evidence that more than one glaciation had occurred in the Henty Basin came from ^{14}C dates on lacustrine organic clays overlying weathered till at Henty Bridge (fig. 1) (Colhoun 1985b). Dates of 23 640 ± 1030 yrs (GaK 5597) to >34 600 yrs BP (GaK 5595)

confirmed that the underlying deposits predated the Last Glacial Maximum (LGM); the relative degree of till clast weathering and the thick, partially weathered screes overlying the Henty sediments strongly suggested a pre-Last Interglacial, rather than an early Last (Margaret) Glaciation age (Colhoun 1985b). This was supported by analyses of recently discovered interglacial deposits at Langdon River that indicated a mixed wet forest at the site (Colhoun *et al.* 1988). The site is located 1 km beyond the LGM end moraines and 5 km upvalley from the limits of the Henty Glaciation. Wood from the surface of the interglacial deposit was dated at 41 900 +1000, –900 yrs BP (SUA 2277), and an amino-acid assay suggested an age of Isotope Stage 7, with the Henty Glaciation inferred to predate this.

Colhoun & Fitzsimons (1990) and Pollington (1991) suggested that reversed detrital remanent magnetisation recorded in rhythmites at Tyndall Creek (fig. 1), in sediment regarded as being of Henty Glaciation affinity, indicated that the deposits at Henty Bridge may pre-date those elsewhere in the West Coast Range that have been referred to as belonging to the Henty Glaciation. However, re-examination of the Tyndall Creek site by the authors indicated that the stratigraphy of the site is more complex than had previously been recognised. Deeply weathered glacial sediments, possibly the equivalents of the still older Linda (King Valley) and Bulgobac (Pieman Valley) Drifts, had not previously been recognised in the Henty River Basin but were found to form most of the Tyndall Creek section, being buried by only 2 m of Henty-type till.

An organic deposit at Newton Creek (fig. 1) provided a date of >33 950 yrs BP (Beta 21759), with the trend towards warming, indicated by the pollen and macrofossil record, suggesting that the deposit may represent an interstadial during the early part of the Last Glacial Stage (Colhoun *et al.* 1993). The timing of the LGM from the Pieman and Henty Basins has recently been elucidated from pollen analysis of shallow cores from Lake Selina (fig. 1) (Pola, Colhoun & Barton, unpubl. data). A change from last interstadial to the commencement of climatic deterioration and onset of the LGM has been inferred at 25 000 yrs BP at Tullabardine (Colhoun & van de Geer 1986), with the end of the LGM at Lake Selina dated at 14 200 ± 230 yrs BP (SUA 3040). Similarly, at nearby Lake Johnston, the deglaciation of the basin had occurred by 9430 ± 110 yrs BP (SUA 2987) (Anker 1991), and by at least 11 420 ± 770 yrs BP (GaK 6297) at Poets Hill Lake adjacent to the Hamilton End Moraine (Colhoun 1992). The LGM glaciers did not penetrate west of the West Coast Range, unlike the older and far more extensive Boco (formerly the Boco 2 Glaciation of Augustinus & Colhoun 1986), Bobadil (formerly the Boco 1 Glaciation of Augustinus & Colhoun 1986) and Bulgobac glaciers in the Pieman Basin (Augustinus & Colhoun 1986, Augustinus *et al.* 1994). Sharp-crested LGM end moraines are found below Mts Read and Murchison and at the southern end of the Tyndall Plateau (the Hamilton End Moraine) (fig. 1). No evidence for an early Last Glacial advance, such as that argued for the King Valley (Chamouni Glaciation) by Fitzsimons & Colhoun (1991), has been recognised from the Henty Basin.

METHODS USED IN STUDY

The application of relative dating techniques to the discrimination and mapping of drift sheets from the Henty Basin is largely hampered by the paucity of dolerite and other lithologies that develop sharply defined weathering rinds. The absence of dolerite from the upper Henty Basin means that the quantification of weathering rind thicknesses, so successful in allowing the mapping of glacial drift sheets elsewhere in western Tasmania (i.e. Kiernan 1983, Kiernan 1989) was not applicable here. The degree of weathering of Cambrian volcanic clasts from the Pieman Basin was used by Augustinus & Colhoun (1986) to discriminate successfully between drift sheets of different relative ages when used in conjunction with a range of other post-depositional weathering criteria. Cambrian volcanics (together with Ordovician conglomerates) dominate the upper Henty Basin and are the major source of clasts found in the drifts there.

Hence, we use the relative degree of Cambrian volcanic clast alteration as a tool to enable identification of drift sheets of differing relative ages from the Henty Basin, and for correlation of the glacial drifts mapped from both the Pieman and Henty River Basins. The relative degree of clast alteration was quantified by following the methods detailed in McGregor (1981) and Augustinus & Colhoun (1986). These methods are:

(1) percentage absorption (%Ab) of water by volcanic clasts, which refers to the volume of water that a rock clast can absorb (the more water the clast absorbs, the more it has been altered by the removal of easily weathered minerals); and

(2) specific gravity (SG) of volcanic clasts, which also varies with degree of clast weathering, as unstable minerals are altered and the products removed.

The variations in %Ab and SG reflect porosity and void development, and indicate the degree of weathering of the host drift (McGregor 1981). Where possible, clast samples were taken from a uniform 1 m depth in the drift exposures. The weathering front was in all cases deeper than the sample sites, with little apparent variation in degree of clast alteration down profile, so any variation in sampling depth probably had no significant influence on the results. One to two kilogram samples of 4–8 cm diameter Cambrian volcanic clasts were taken from the drift at each site, so that mineralogical (crystal size and composition) variations between the clasts could be averaged out.

Other post-depositional weathering criteria used for the differentiation of Henty Basin drift sheets include till matrix colour, degree of Fe/Mn oxide panning in the drift, dolerite weathering rind thicknesses (where appropriate) and moraine morphology. The details of these techniques were given in Augustinus & Colhoun (1986) and are used here to support drift separation based on qualitative observations of relative degrees of drift modification.

RESULTS AND DISCUSSION

Observations on the relative degree of weathering of the drifts from the Henty River Basin suggest the development of at least three distinct drift sheets of differing relative age beyond the LGM limits. The most useful methods for separating the drift sheets were quantitative evaluation of state of clast alteration, degree of iron panning and clast Fe oxide staining, topographic position and degree of modification of moraine morphology (table 1).

TABLE 1
Late Cenozoic glacial stratigraphy, Henty River Basin, western Tasmania

Glacial events	Magnet-isation	^{14}C (kyrs)	Amino acid	Jdl* weathering rind thickness max. (mm)	%Ab	Specific gravity	Degree of Fe oxide development	Weathering front
Margaret†		18.8		–	–	–	none	<1
Interstadial‡		>34						
Julia Drift				–	–	–	minor Fe	<2
Langdon Interglacial§		>41.9	Stage 7					
Henty Drift		>34.6¶		15	2.7–14.5	2.10–2.45	thin Fe pans	2–4
>783 kyrs								
Berry Creek Drift	reversed#			30	14.4–20.8	1.95–2.05	thick Fe pans	not exposed >4

* Jdl = dolerite. † Colhoun (1985a). ‡ Colhoun *et al.* (1993). § Colhoun *et al.* (1988).
¶ Colhoun (1985b). # Pollington (1991).

The presumed youngest and least extensive of the drift sheets displays minimal clast alteration, absence of Fe/Mn oxide panning and limited Fe staining of clasts. The till matrix is weathered to yellowish grey (2.5YR6/1; Standard Soil Colour Chart) and a 2 m weathering front was observed (table 1). The morphology is hummocky and minimally modified, and is only developed on the higher parts of the Henty Surface, southwest of Mt Julia (fig. 2). This drift is termed the Julia Drift, after the type site on Howards Road 600 m west of Mt Julia (Selina 3836 – 1:25 000; Universal Grid Reference 55G CP 801615). It is located beyond the limit of the LGM moraines on the Tyndall Range and Mts Murchison and Read, and the >33 950 yrs BP date from Newton Creek (Colhoun *et al.* 1993) indicates that the drift has an age beyond the limit of ^{14}C.

Beyond the Julia Drift, on the Henty Surface, is the most extensive and best displayed of the drift sheets — the Henty Drift (fig. 2). The clast composition is dominated by Cambrian volcanics and Ordovician Owen Conglomerate, with the former displaying a significantly greater degree of clast alteration than is displayed by the Julia Drift. No dolerite was encountered, and Fe/Mn oxide panning is common, with clay skins commonly developed on volcanic clasts (table 1). The till matrix is weathered to reddish brown (2.5YR4/8) and the depth to weathering front measures 2–4 m. The drift surface is hummocky, and a nearly continuous ground cover is maintained, although without clear end moraines. This drift sheet is best displayed at the Henty Bridge and at the Anthony Dam Road–Zeehan Highway intersection and is considered to represent the Henty Drift described by Colhoun (1985a, b). Consequently, the name Henty is maintained for the drift at this site, and Henty Bridge remains the type site.

One kilometre north of Henty Bridge, on the Zeehan Highway, the drift exposures change: moderate degrees of weathering give way to a deeply altered diamicton containing totally decomposed Cambrian volcanic clasts of up to 0.25 m diameter. The till matrix is weathered to bright yellowish brown (10YR6/8) and strong Fe oxide panning is developed (table 1). The depth to the weathering front was not observed in this drift. The drift exposure at Tom Creek and adjacent Berry Creek contains up to 40% dolerite clasts with alteration rims of up to 3 cm thickness, but most exposures along this section of highway contain only occasional dolerite clasts. The drift remnants are fragmentary, and no moraine morphology has been preserved. Colhoun (1979) termed this the Tom and Berry lobe of the Henty Glaciation.

This drift sheet persists beyond the limits of the Henty Drift and represents the most extensive glacial episode to have drained into the Henty Basin via the Tyndall Plateau (fig. 2). Previously undefined, this drift sheet is termed

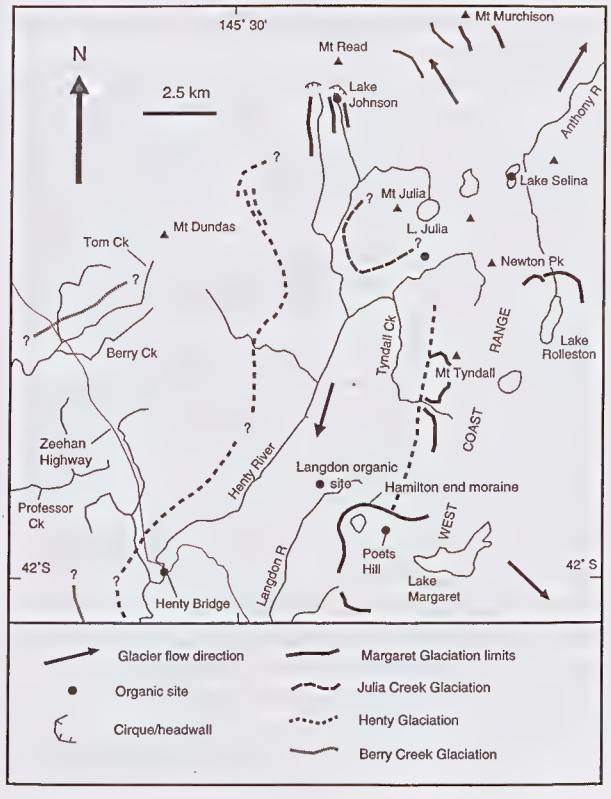

FIG. 2—Glacial drift limits, Henty River Basin

here the Berry Creek Drift, after its type site immediately north of Berry Creek on the Zeehan Highway (Oceana 3635 – 1:25 000; UGR 55G CP702568). Hammond (1985) recognised deeply altered clasts in till at Professor Creek (fig. 2) and suggested that the deposits at this site pre-date the Henty till at Henty Bridge and may correlate with the Linda till from the King Valley, because of a similar gross state of clast weathering. Hence, the deeply altered till from this site probably correlates with the Berry Creek Drift exposed on the nearby Zeehan Highway and further supports the subdivision of the Henty drift into at least two glacial drift sheets of differing relative age.

SUPPORT OF DRIFT SHEET MAPPING USING PERCENTAGE ABSORPTION AND SPECIFIC GRAVITY

Augustinus & Colhoun (1986) plotted %Ab against SG values from Cambrian volcanic clasts in the Pieman River Basin as a scatter graph, and obtained a straight line relationship with three identifiable populations. These groupings supported other post-depositional weathering evidence for at least three distinct drift sheets (Augustinus & Colhoun 1986). The %Ab and SG data showed that the penultimate Boco Glaciation Drift could be discriminated clearly from the much more extensively altered Bulgobac Drift. The latter displays reversed detrital magnetisation and is hence >783 kyrs old (Pollington 1991, Baksi *et al.* 1992), although the overlap between the SG and % Ab results from the Bobadil Drift (formerly termed Boco I in Augustinus & Colhoun 1986) and the Bulgobac and Boco Drifts suggests that the method will only allow the confident discrimination of drifts separated by a long weathering interval equal to at least one glacial–interglacial cycle. The discrimination power of the method declines with variability in degree of clast alteration between sites.

Figure 3A shows the %Ab versus SG plot for all sites from the Pieman Basin, whilst figure 3b shows both the Henty and Pieman River Basin drift sheet data. Examination of figure 3B indicates that the Henty Drift data correlate well with the Bulgobac and Bobadil Drift results from the Pieman Basin, with the Boco sites generally having significantly lower %Ab and higher SG values. This suggests a greater relative age for the widespread Henty Drift exposed along the Anthony Dam Road than for the Boco Drift from the Pieman Basin.

The Berry Creek Drift displays a very high degree of weathering and clast alteration with many of the Cambrian volcanic clasts of up to 0.25 m diameter weathered to ghosts. Volcanic clasts selected from six sites in this deeply altered diamicton were examined; their %Ab and SG values are plotted in figure 3b. At all but one site, the clasts display a significantly greater degree of weathering than than do those from the Henty Drift, and the degree of alteration is comparable to that of the Bulgobac Drift from the Pieman Basin. This is supported by the degree of weathering of dolerite clasts from these sites. Dolerite clasts comprise up to 40% of the ice-proximal coarse gravel exposed immediately south of Tom Creek (fig. 2) and weathering rinds up to 30 mm thick were measured, although most of the clasts have been disturbed so that the "true" dolerite weathering rind thicknesses have probably not been measured.

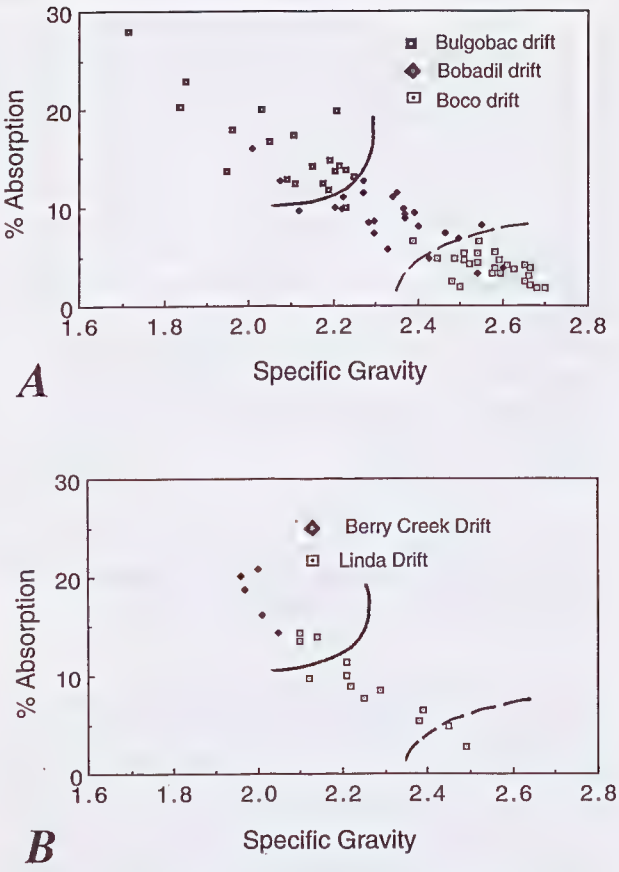

FIG. 3 — Plots of specific gravity versus percentage absorption for volcanic clasts: (A) clast values from Pieman River Basin sites; (B) clast values from the Henty River Basin. Lines delineating fields representing range of specific gravity and % absorption values for the Pieman Basin drifts indicated: solid lines = Bulgobac Drift, dashed lines = Boco Drift.

DATING AND INTER-BASIN CORRELATION OF THE DRIFT SHEETS

Measurement of SG and %Ab of volcanic clasts from the glacial drift sheets in the Pieman and Henty River Basins supports the mapping of several distinct drift sheets using several other post-depositional weathering criteria. In the Pieman Basin, clear differentiation between the Boco and Bulgobac Drifts is possible, although overlap with both occurs when volcanic clasts from the Bobadil Drift are examined. The two extensive glacial drifts from the Henty Basin can be more confidently mapped on the basis of differences in %Ab and SG and assigned to drift sheets of different relative age.

The most extensive and deeply weathered drift from the Henty Basin displays a degree of clast alteration comparable with that of the Bulgobac Drift from the Pieman Basin, although there is significant overlap between the groupings, as would be expected given the variability in clast mineralogy, topography and microclimate at each site. Hence, the older, deeply weathered drift from the Henty Basin (Berry Creek Drift) is tentatively correlated with the Bulgobac Drift from the Pieman Basin (table 2). Dolerite is common in the Berry Creek Drift but not the Henty

Drift: it was probably derived from supraglacial debris added to the lateral margins of the extensive Berry Creek piedmont glacier when the western margin abutted the dolerite-capped Mt Dundas.

Presence of reversed detrital remanent magnetisation (DRM) in Henty Drift glaciolacustrine sediments from Tyndall Creek suggested to Colhoun & Fitzsimons (1990) that the Henty Glaciation may pre-date the Brunhes–Matuyama boundary. However, re-examination of the site by the present authors indicates that the rhythmites contain ice-push structures and display clear evidence that the basal rhythmites, from which the reversed DRM results were obtained, were overridden. The basal diamicton displays a degree of clast alteration comparable to that of the Berry Creek Drift, whilst the upper diamicton displays a significantly lower degree of clast alteration and is identical to the Henty Drift mapped elsewhere on the Henty Surface. Hence, the site is interpreted as representing Berry Creek Drift (including glaciolacustrine rhythmite) with an age >783 kyrs, which was later overridden by the Henty Glacier, resulting in deformation of the older rhythmites. This phase terminated with the deposition of indurated basal till of Henty Glaciation affinity. No rhythmite has been found associated with the Henty Drift in the Henty Valley.

The Henty Drift has the most widespread exposure of any of the Henty Basin drifts and displays clast alteration values comparable with those of the Bobadil Drift from the Pieman Basin; a tentative basin-wide correlation between the two drifts is suggested here (table 2). This correlation is supported by an amino-acid assay on wood from the Langdon River organic site, which is developed on the floor of a meltwater channel lined with laminated silts and clays associated with the Henty Drift. The amino-acid assay suggests Isotope Stage 7 age for the organic site (B.J. Pillans, pers. comm. 1988) and at least Stage 8 for the Henty Glaciation. The Bobadil Glaciation has been dated to Isotope Stage 8 on the basis of bracketing U/Th dates of 166 +41, –33 kyrs (LH 2460) and 279 +100, –65 kyrs (LH 2461)(Augustinus *et al.* 1994). If the correlations between basins based on post-depositional weathering criteria are correct, the Henty Glaciation can be more securely assigned to Isotope Stage 8 than to Stage 6, as suggested previously (Colhoun 1985a,b).

The Bobadil Drift from the Pieman Basin displays normal DRM and is <783 kyrs (Pollington 1991, Augustinus *et al.* in press). U/Th dating of ferricrete bands associated with Bobadil Glaciation sediments from the Boco Plain indicates a probable Isotope Stage 8 age for the glacial event

TABLE 2
Late Cenozoic glaciations of Pieman and Henty River Basins

Series subdivision	Pieman Basin*	Henty Basin
Late Pleistocene	Margaret Glaciation	Margaret Glaciation max. ~19 kyrs †
	Interstadial 25-44 kyrs ‡	Interstadial >34 kyrs §
	—	(Julia Ck Glaciation ?)
	Pieman Interglacial amino acid Isotope Stage 5 #	–
	Boco Glaciation >78, <166 kyrs	(Julia Ck Glaciation ?)
	–	Langdon Interglacial Isotope Stage 7 #
Middle Pleistocene	Bobadil Glaciation Core AK1 >13 m >166, <279 kyrs	Henty Glaciation >34.6 kyrs †
	Animal Ck Glaciation Core AK1 >41 m >279 kyrs	
B/M Boundary 783 kyrs		
Early Pleistocene	Bulgobac/Que Glaciations reversed magnetisation ∫	Berry Ck Glaciation reversed magnetisation ∫

* Augustinus et al. (1994). † Colhoun (1985a). ‡ Colhoun & van de Geer (1986). § Colhoun *et al.* (1993). ¶ Colhoun & Fitzsimons (1990). # Colhoun *et al.* (1988). ∫ Pollington (1991).
AK1 refers to Pasminco drill core from Boco Plain, with depths to U/Th dated horizons.

(Augustinus *et al.* 1994). The Bobadil Drift is clearly of middle Pleistocene age, and correlation between the Bobadil and Henty Drifts seems reasonable on the basis of the amino-acid assays and clast weathering data from the Henty Basin (table 2). However, it is not possible to exclude correlation of the Henty Drift with the younger Boco Drift (Isotope Stage 6) from the Pieman Basin without better dating of the Henty Basin sequences.

The Julia Drift extends beyond the LGM end moraines and displays a distinctly lower degree of post-depositional alteration than the much more extensive and more weathered Henty Drift (table 1). Dating of this drift is not possible at this time. It could represent either an early Last Glacial ice advance, similar to that postulated for the Chamouni Formation from the King Valley (Fitzsimons & Colhoun 1991), or it could belong to Isotope Stage 6. In the absence of firm dating of these drifts, it is not possible to determine the age with confidence.

CONCLUSIONS

Re-evaluation of the glacial stratigraphy of the Henty Basin has enabled the mapping of at least three drift sheets of pre-Last Glacial Maximum age, using relative degree of clast alteration, Fe panning, degradation of the moraine morphology and topographic position. The Berry Creek Drift represents the oldest and most extensive glaciation identified in the basin, although its distribution is fragmentary, as is the case with the similarly extensive Bulgobac Glaciation from the Pieman Basin.

The Henty Drift is much more widespread, is tentatively correlated with the Bobadil Drift from the Pieman Basin and is dated to the middle Pleistocene. The Henty Drift pre-dates Isotope Stage 7, and, presuming that the weathering evidence for correlation between the Henty and Bobadil Drifts is valid, an Isotope Stage 8 age can be assigned to both drifts. The Julia Drift is restricted in extent, displays minimal clast and matrix alteration and is located well beyond the distinct LGM (Margaret Glaciation) end moraines below Mt Read, Mt Murchison and the Tyndall Plateau. Dating of this drift is problematical, since weathering evidence suggests an age younger than the Henty Drift, but no datable material has been found to test this interpretation.

Although the measurement of clast SG and %Ab does not permit discrimination between drifts, unless one has been exposed to prolonged periods of weathering equivalent to at least the duration of one interglacial episode, it does allow clear separation of the middle Pleistocene Henty/Bobadil from the early Pleistocene Berry Creek/Bulgobac Drifts. Although the drifts from the Henty Basin are mostly devoid of dolerite clasts, it has been shown that these methods, when used with at least one other relative-dating test, provide the best means of differentiation and correlation between the drift sheets.

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MIOCENE *WILKINSONIA* FRUITS (HICKSBEACHIINAE, PROTEACEAE) FROM THE BASE OF THE YALLOURN FORMATION, LATROBE VALLEY, VICTORIA

by Andrew C. Rozefelds

(with two tables, one text-figure and one plate)

ROZEFELDS, A.C., 1995 (30:vi): Miocene *Wilkinsonia* fruits (Hicksbeachiinae, Proteaceae) from the base of the Yallourn Formation, Latrobe Valley, Victoria. *Pap. Proc. R. Soc. Tasm.* 129: 59–62. ISSN 0080–4703. Tasmanian Herbarium, GPO Box 252C, Hobart, Tasmania, Australia 7001.

Wilkinsonia bilaminata F. Muell., 1879 is recorded from interseam clays at the base of the Yallourn Formation, Latrobe Valley, Victoria. The genus was widely distributed throughout eastern Australia during the Oligo-Miocene. The palynological record for both Yallourn and the type locality has not suggested that either *Athertonia*, the most closely related extant taxon, or the subtribe Hicksbeachiinae were present in these localities. There are two inferences from these results; the suggested affinities of some of the pollen taxa may be in error, or the pollen of the *Wilkinsonia* plant may be under-represented in these sites and has been overlooked.

Key Words: Proteaceae, Hicksbeachiinae, *Athertonia*, *Wilkinsonia*, fossil fruit, Victoria, Australia, Tertiary, biostratigraphy.

INTRODUCTION

Wilkinsonia bilaminata was described by Mueller (1879, 1883) on the basis of woody fruits from deep leads, below basalts in the Orange and Gulgong gold-mining areas of New South Wales. Since then similar fruits have been collected from Glencoe, in Central Queensland, and the status of the genus has been re-examined following comparisons with the extant genera *Athertonia* and *Heliciopsis* in the subtribe Hicksbeachiinae (Rozefelds 1990a, 1992). *Wilkinsonia* was shown to be more closely related to the modern genus *Athertonia*, a rainforest endemic restricted to northeastern Queensland (Rozefelds 1992).

Fossil fruits referable to *Wilkinsonia* have been recently collected from the interseam clays at the base of the Yallourn Formation. Palynological studies of interseam clays at the base of the Yallourn Formation indicate a late early to middle Miocene age based on the presence of *Triporopollenites bellus* Zone and the first appearance of *Proteacidites symphyonemoides* (Sluiter 1984). Partridge (pers. comm.) in Macphail *et al.* (1994) gives an absolute date of 17.0 myrs BP for the base of the Yallourn Coal Seam. The interseam clays are approximately equivalent in age, based upon pollen, to the type locality for *Wilkinsonia bilaminata* at Gulgong (McMinn 1981). Potassium–argon dates of 14.8 ± 1.2 and 13.8 ± 1.1 myrs BP for basalts in the Gulgong area that overlie deep leads in this area (Dulhunty 1971) indicate a minimum mid-Miocene age for this flora.

The seed/fruit flora and other plant fragments occur in medium to fine-grained clastics of fluvial or lacustrine origin (Blackburn & Sluiter 1994). The associated seed/fruit flora from these interseam clays is diverse but remains unstudied. The seed/fruit flora from the base of the Yallourn Formation includes taxa with affinities to *Elaeocarpus* (Elaeocarpaceae), Vitaceae, Menispermaceae and *Glochidion?* (Euphorbaceae).

In this paper, *Wilkinsonia bilaminata* is recorded from the Miocene clays in the Latrobe Valley. The new material provides additional information on the morphology of the endocarps not evident from the neotype. The biogeographical significance of this new *Wilkinsonia* record is discussed. The biostratigraphic range of this taxon is also discussed, along with the potential for developing seed/fruit-based biostratigraphies. Yallourn fossils described in this paper have been deposited in the Museum of Victoria.

FIG. 1 — Localities mentioned in text and distribution (arrowed) of modern Athertonia *in Australia.*

SYSTEMATIC PALAEOBOTANY

Family PROTEACEAE
Tribe MACADAMIEAE
Subtribe HICKSBEACHIINAE
Wilkinsonia F. Muell., 1879

Type species: *Wilkinsonia bilaminata* F. Muell., 1879.

Wilkinsonia bilaminata F. Muell., 1879.

1879 *Wilkinsonia bilaminata* F. Muell., p. 170, pl. 3, fig. 4a, b.
1883 *Wilkinsonia bilaminata* F. Muell., p. 7, pl. 3.
1992 *Wilkinsonia bilaminata* F. Muell., emend. Rozefelds, p. 196.

Material examined
NMVP199574–NMVP199578, Base of Yallourn Formation, interseam clays from between the Yallourn and Morwell coal seams, collected from near the top of the Morwell Open Cut Coal Mine, Latrobe Valley, Victoria. *Triporopollenites bellus* Zone (pl. 1A–H).

Description of Yallourn material
The endocarps from Yallourn are large, irregularly round to oval in outline, with reticulate lacunose ornamentation. The size of the endocarp varies from 38.5–42 mm long and 36.7–41 mm wide (table 1). Endocarps appear slightly compressed but are elliptical in lateral view. A prominent incipient lateral ridge extends from the apex to the base on either side of the endocarp (pl. 1A–H). A relatively broad lateral field occurs between the incipient ridge and the edge of the endocarp, with minor accessory lateral ridges and irregular rows of small depressions (pl. 1A–H). The width of this region may be different on one side of the endocarp from that on the other within the one specimen (table 1). This lateral field in the Yallourn material extends beyond the rest of the endocarp, forming a slight notch (pl. 1A–H). Multiple irregular rows of depressions and poorly defined ridges occur between the lateral ridge and the edge of the endocarp. The endocarp wall, which is 2–3 mm in thickness, consists of tangentially oriented interweaving fibres. The bases of additional, weakly lignified fibres occur in the lacunae. These fibres extend outwards into what was the fleshy mesocarp of the fruit. Fragments of endocarp examined with the SEM failed to provide additional data on the microstructure in these endocarps.

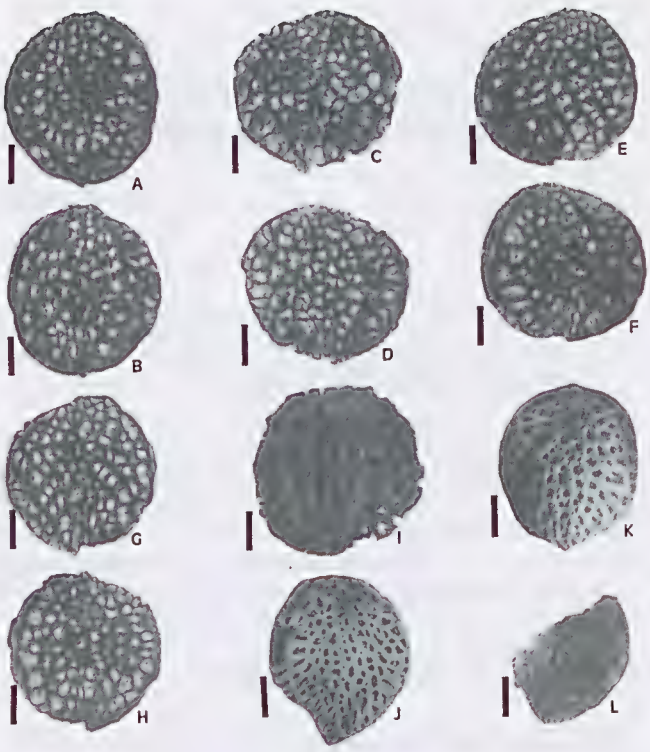

PLATE 1
Wilkinsonia *and* Athertonia *endocarps. (A–H, L)* Wilkinsonia bilaminata *F. Muell. from the interseam clays at the base of the Yallourn Formation.*
(A, B) NMVP199577. (C, D) NMVP199574. (E, F) NMVP-199576. (G, H) NMVP-199575. (I) Neotype of Wilkinsonia bilaminata *(NMVP-53092) from the Black Lead, approx. 43-52 m below basalt, Gulgong, New South Wales. (J, K) Extant endocarps of* Athertonia diversifolia *(C.T. White) L. Johnson and B. Briggs. (L) Fragment of* W. bilaminata *(NMVP 199578) from Yallourn. Scale bars = 10 mm.*

Remarks
The features that allow referral of these fossil endocarps to *Wilkinsonia* are the lacunose ornamentation and the continuous lateral ridge that extends from the apex to the base of the endocarp. The new material from Yallourn is closely comparable to the neotype (NMVP53902) of *W. bilaminata* from the Gulgong locality. Additional material of *W. bilaminata*, figured or mentioned by Mueller (1879, 1883) from Beneree in New South Wales, has not been located.

TABLE 1
Measurements of Yallourn *W. bilaminata* F. Muell.

Registration Number (NMV)	Length (mm)	Width (mm)	Maximum width of lateral fields (mm) one side	other side
P199574	38.6	40	10.7	9.7
P199575	38.5	36.7	9.0	8.4
P199576	39.2	41	10.8	10.5
P199577	42	37.4	10.8	8.0

Two species of *Wilkinsonia* are recognised (Rozefelds 1992). Both taxa share multiple irregular rows of small depressions, with accessory ridges occurring between the incipient ridge and the edge of the endocarp. The two species differ in the width of the lateral field between the incipient ridge and the edge of the endocarp. In *W. bilaminata* this zone is broad, while in *W. glencoensis* it is relatively narrow (Rozefelds 1992). The additional material from Yallourn shows variation in the width of this region. The new material from Yallourn also provides additional differences between these taxa. The base of the endocarp in *W. bilaminata* is slightly notched, and the lateral field extends further than the main region of the endocarp (pl. 1A–H). The notch is absent from *W. glencoensis*. The neotype of *W. bilaminata* from Gulgong was also strongly flattened, as well as damaged, due to pyritic deterioration in storage; this made comparison with *W. glencoensis* difficult. The new material of *W. bilaminata* does not show the weakly defined longitudinal ridges seen in the neotype. These longitudinal ridges were initially considered to be due, in part, to compression (Rozefelds 1992). This interpretation is supported by the new material from Yallourn, as the lacunose ornamentation of the endocarps is irregular and does not form ridges. The weakly defined longitudinal ridges in the neotype are considered to be preservational artifacts.

The Proteaceae pollen taxa described from both the Home Rule site and the interseam clay between the Yallourn and Morwell Coal Measures are recorded (table 2). The Proteaceae pollen taxon shared between these sites is *Proteacidites symphyonemoides*, which has been considered by Martin (1978) to have affinities with *Symphionema* (subfamily Proteoideae). The other Proteaceae pollen taxa known from either the Yallourn Formation or Home Rule locality are not considered to have affinities with *Athertonia* or Hicksbeachiinae. There is no evidence for linking any of the known pollen taxa and endocarps to the same parent plant (table 2).

The fossil distribution of *Wilkinsonia* demonstrates that proteaceous plants with endocarps closely comparable to extant *Athertonia* were widespread in eastern Australia during the Oligo–Miocene (fig. 1). *Athertonia*, the extant taxon most closely related to *W. bilaminata*, occurs in the tropical rainforest communities of northeastern Queensland (Rozefelds 1992). The discovery of *W. bilaminata* at the base of the Yallourn seam, and *Elaeocarpus* and Menispermaceae endocarps, Vitaceae seeds, and possibly *Glochidion* fruits (Rozefelds 1990b, pers. obs.) indicates that forests with affinities to tropical-warm temperate closed forests occurred in the Yallourn area during the mid-Miocene.

Discussion

While considerable advances have occurred in palynological studies of the Latrobe Valley Coal Measures (Luly *et al.* 1980, Sluiter & Kershaw 1982, Macphail *et al.* 1994), the megaflora and local plant communities that gave rise to these units remain poorly known (Blackburn & Sluiter 1994). The new megafloral material allows recognition of the subtribe Hicksbeachiinae in these units, something not suggested by the existing pollen studies. This failure to identify plants with affinities to *Athertonia* and the Hicksbeachiinae in the pollen flora could be due to either the pollen of these trees being under represented in the palynofloras or, alternatively, to the proposed generic affinities of some Proteaceae pollen being in error. Some support for the earlier proposition comes from Kershaw (1973) and Walker & Flenley (1979), who considered the Proteaceae to be equally or under-represented in fossil units, and this is consistent with the low mobility of Proteaceae pollen (Kershaw & Strickland 1990). Kershaw (1973) and Walker & Flenley (1979) also considered that the source of Proteaceae pollen was from locally growing trees. The possibility of locally growing source trees for pollen is consistent with the unabraded condition of the fruits. It is somewhat surprising, therefore, that pollen of these trees has not been identified in the palynofloras. Hence, it is considered equally likely that the supposed generic affinities of at least one of these pollen types may be in error.

The palynomorph *Propylipollis reticuloscabratus* (Harris) was considered by Dettmann & Jarzen (1991) to be closely comparable to pollen of *Hicksbeachia/Gevuina*. Specht *et al.* (1992) recorded the stratigraphic range of *Hicksbeachia/Gevuina* pollen type from the Campanian through to the Pliocene in southeastern Australia. This pollen type was considered morphologically distinctive by Dettmann & Jarzen (1991). Johnson & Briggs (1975), however, placed these extant genera in two separate subtribes, i.e. *Hicksbeachia* (subtribe Hicksbeachiinae) and *Gevuina* (subtribe Gevuininae). The significance of this pollen type

TABLE 2
Proteaceae pollen taxa recorded

Home Rule Deposit, Gulgong*	Core LY1279, Latrobe Coal Measures †	Suggested affinity ‡
Proteacidites ivanhoensis	–	*Orites, Helicia, Macadamia*
P. symphyonemoides	*P. symphyonemoides*	*Symphionema*
	P. tuberculatus	
	P. obscurus	*Agastachys* type
	P. sp cf. *callosus*	
	Beauprea	*Beauprea*
	Banksia/Dryandra	*Banksia, Dryandra*

* From the *Triporopollenites bellus* Zone at Gulgong (McMinn 1981).
† From the base of the Yallourn Formation (Sluiter 1984).
‡ Martin (1978) and Macphail *et al.* (1994).

in relation to the existing tribes recognised by Johnson & Briggs (1975) is unclear and requires further study.

The new record of *Wilkinsonia*, unpublished results for *Elaeocarpus* (Elaeocarpaceae) (Rozefelds 1990b) and *Rhytidocaryon wilkinsonii* (Menispermaceae) (Rozefelds, pers. obs.), and their relationship to existing palynological biostratigraphic zones demonstrate the potential for developing seed/fruit biostratigraphic-based systems for the Tertiary of southeastern Australia. There is a relative paucity of records of pollen/spores and megafossil material in organic connection in the Australian Tertiary (Christophel 1984, Rozefelds *et al.* 1992). The development of fruit/seed taxa, or leaf and dispersed cuticle zones, in conjunction with palynological studies would provide the opportunity to test the biostratigraphic framework proposed by either palynologists or megafossil workers. The association of different organ taxa in the same geological units would also allow the parent plant and plant communities to be more accurately reconstructed. Systematic data from a number of organ taxa of the same parent plant would also permit more rigorous comparisons with the extant flora and better phylogenetic conclusions to be drawn.

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NEW TAXA AND NEW RECORDS FROM THE TASMANIAN LICHEN FLORA

by John A. Elix and Gintaras Kantvilas

(with three plates)

Elix, J.A. & Kantvilas, G., 1995 (30:vi): New taxa and new records from the Tasmanian lichen flora. *Pap. Proc. R. Soc. Tasm.* 129: 63–68. ISSN 0080–4703. Department of Chemistry, Australian National University, Canberra, ACT, Australia 0200 (JAE); Tasmanian Herbarium, GPO Box 252C, Hobart, Tasmania, Australia 7001 (GK).

Three new lichens from Tasmania, *Cladonia sulcata* var. *depleta* Elix & Kantvilas, *Parmelia tarkinensis* Elix & Kantvilas and *Xanthoparmelia jarmaniae* Elix & Kantvilas are described. Eleven additional taxa are reported from Tasmania for the first time, and notes on their distinguishing features, distribution and ecology are provided.
Key Words: lichens, flora, *Cladonia, Parmelia, Xanthoparmelia*, Tasmania.

INTRODUCTION

Since the publication of the latest checklist of Tasmanian lichens (Kantvilas 1994), further collecting and floristic, ecological and taxonomic research on the flora has continued, resulting in a number of additions to the Tasmanian census. In the present paper we describe a new corticolous species in the genus *Parmelia*, a new saxicolous species of *Xanthoparmelia* and a new variety of *Cladonia*, and report 11 taxa from Tasmania for the first time.

METHODS

The study is based primarily on collections in the Tasmanian Herbarium (HO) and the Australian National Herbarium (CANB). For all taxa, determinations are based on comparisons with type and/or reliably identified reference material. Anatomical and chemical investigations follow standard methods.

TAXONOMY

Buellia badia (Fr.) Massal., *Memor. Lichenogr.* 1853:124 (1853) — *Lecidea badia* Fr., *Syst. Orb. Veget.* 1: 287 (1825)

Buellia badia is characterised by a dark-brown, areolate-crustose to small-squamulose thallus, black, lecideine apothecia, a hymenium lacking oil droplets, and brown, 1-septate ascospores, 10–15 × 7–8.5 µm, which lack lateral thickenings (for further descriptive data, Scheidegger 1993; for an illustration, Wirth 1987).

This species is widespread in the Northern Hemisphere and is also known from New Zealand. It is typically lichenicolous on a wide range of foliose and crustose lichen genera (Scheidegger 1993). The Tasmanian record is from the thallus of *Tephromela atra* on sandstone outcrops in dry sclerophyll forest.

Specimen examined
C. 3 km southeast of Broadmarsh, 42°41'S, 147°09'E, 60 m, 11 December 1993, G. Kantvilas 157/93 & J.A. Elix (HO).

Candelariella aurella (Hoffm.) Zahlbr., *Catal. Lich. Univ.* 5: 790 (1928) —*Verrucaria aurella* Hoffm., *Deutsch. Fl.*: 197 (1796)

Candelariella aurella is characterised by a yellow to greenish-grey, granular to evanescent thallus, and apothecia with eight-spored asci (for descriptions, Filson 1992, Purvis *et al.* 1992, Galloway 1985). The species is cosmopolitan and occurs on limestone or, more commonly, on man-made substrates such as concrete or asbestos. Although currently known in Tasmania from only a single specimen from mortar, and in mainland Australia from a sole collection from South Australia (Filson 1992), the species is likely to be more widespread in urban areas.

Two other species of *Candelariella* occur in Tasmania: *C. xanthostigmoides* grows on bark and has a granular to sorediate thallus and eight-spored asci, whilst *C. vitellina* (see below) occurs on siliceous rocks and has polyspored asci.

Specimen examined
Hobart, 9 Lallaby Road, Moonah, 1965, G.C. Bratt 1919 (HO).

Candelariella vitellina (Hoffm.) Müll. Arg., *Bull. Herb. Boissier* 2, App. 1: 47(1894) — *Patellaria vitellina* Hoffm., *Descr. Pl. Cl. Crypt.* 2: 5 (1794)

Candelariella vitellina is a widespread cosmopolitan lichen, recognised by its polyspored asci, usually containing 12–32 ascospores, and by its saxicolous habitat. The species is morphologically very variable, with greenish-yellow to golden-yellow areolae, which may be either dispersed or clustered into thick pulvinate clumps (for full description, Galloway 1985). Although specimens from alpine and subalpine areas tend to have a thicker, more prominent thallus (Filson 1992) as well as somewhat larger apothecia (up to c. 0.8 mm diam. in comparison to < 0.5 mm in the lowlands), there appears to be no consistent correlation between thallus morphology and ecology. Nor are the morphological differences supported by anatomical differences.

In Tasmania, *C. vitellina* is widespread in central and eastern areas from lowland to alpine altitudes. It grows on exposed sandstone and dolerite outcrops in heathland and open sclerophyll woodland, frequently in bird-perching sites. In mainland Australia, this species is common on rocks in South Australia, Victoria, New South Wales and the Australian Capital Territory.

Selected specimens examined (total = 10)
Near Carr Villa, Ben Lomond, 41°31'S, 147°38'E, 26 January 1969, G.C. Bratt 69/81 (HO, AD); Central Plateau, Lake Augusta Dam, 41°51'S, 146°35'E, 1140 m, 7 December 1993, J.A. Elix 40064 & G. Kantvilas (CANB), G. Kantvilas 177/93 & J.A. Elix (HO); Mt Wellington, 42°54'S, 147°14'E, 1260 m, 11 February 1984, G. Kantvilas & P.W. James 300/84 (HO, BM); Maria Island near Darlington, 42°35'S, 148°08'E, 60 m, 12 March 1981, G. Kantvilas 173/81 (HO, BM); Hunting Ground at northwestern end of Middle Tier, 42°32'S, 147°08'E, 180 m, 11 December 1993, G. Kantvilas 169/93 & J.A. Elix (HO).

Cladonia sulcata var. *depleta* Elix & Kantvilas, var. nov. (Pl. 1)

Haec varietas a varietate typic a absentia depsidonicarum differt.

Type
Arthur–Pieman Protected Area, 32 km NNE of Savage River, along the Pipeline Road, 41°16'S, 145°19'E, 480 m elevation, on soil bank along margin of mixed rainforest, 8 December 1993, J. A. Elix 40118 & G. Kantvilas (HO — holotype; CANB — isotype; Lichenes Australasici Exsiccati — isotypes).

Primary squamules persistent or evanescent, 2–5 mm long, 1–2 mm wide, esorediate. Podetia growing from primary squamules, 1–4 cm tall, not scyphose, simple at base, branching above, each branch longitudinally grooved and becoming split, with open axils, rarely with scattered squamules along the podetia, esorediate, greyish white. Cortex continuous at base, becoming finely warted and areolate. Apothecia on the tips of podetia, 0.4–0.8 mm diameter, convex, pale to dark brown; ascospores 10–15 × 3–4 µm. Pycnidia terminal on podetia, black; conidia filiform, 5.5–7.0 × 0.5–1 µm.

Chemistry
K+ yellow, C-, KC-, P+ yellow; containing atranorin (major), bourgeanic acid (major).

This new variety is morphologically indistinguishable from the other three varieties of *Cladonia sulcata* (Archer 1992), but is chemically unique, in that it lacks the depsidones typical of the other three taxa. Thus the major constituents are psoromic acid in *C. sulcata* var. *sulcata*, norstictic acid in *C. sulcata* var. *striata*, and stictic acid in *C. sulcata* var. *wilsonii* (all in addition to atranorin and bourgeanic acid) while *C. sulcata* var. *depleta* lacks any additional depsidones. At present this new variety is only known from the type locality where it is particularly common and luxuriant on disturbed earth at the edge of cool temperate rainforest.

PLATE 1
Cladonia sulcata *var.* depleta *(isotype).*

Hypogymnia australica Elix in J.A. Elix & G.A. Jenkins, *Mycotaxon* 35: 469 (1989)

Hypogymnia australica is characterised by the linear-elongate, di- or trichotomously branched, narrow (1–3 mm wide), hollow lobes which become subcontiguous in the centre of the thallus, the P- medulla, blackened adjacent to the lobe cavity, the absence of perforations in the lower cortex, and the evenly distributed apothecia with swollen, urceolate bases (for description, discussion and illustration, Elix & Jenkins 1989). This endemic Australian species is quite common east of the Great Dividing Range in New South Wales but is either rare or has been previously overlooked in Tasmania. The single record is from a tree trunk in a *Eucalyptus* forest with a thick understorey of *Olearia* and *Leptospermum.*

Specimen examined
Standard Hill, 30 km WSW of Deloraine, 41°33'S, 146°18'E, 440 m, 28 November 1988, J.A. Curnow 2196 (CANB, HO).

Hypotrachyna immaculata (Kurok.) Hale, *Smithsonian Contrib. Bot. 25: 41 (1975)* — *Parmelia immaculata* Kurok. in Hale & Kurokawa, *Contrib. U.S. Nat. Herb.* 36:178 (1964)

This species is distinguished by the sublinear, subdichotomously branched lobes with truncate apices, the prominent capitate soralia, the dense, richly branched dichotomous rhizines, the UV–upper cortex (lacking lichexanthone) and

the presence of the lividic acid complex in the medulla (for a full description, Elix 1994a).

Hypotrachyna immaculata occurs in two sympatric chemical races: one in which lividic acid is preponderant, the other in which colensoic acid and 4-O-methylphysodic acids are the major substances.

This temperate-tropical species is common on rocks and bark in most habitats in eastern Australia (Queensland, New South Wales, Australian Capital Territory and Victoria) and is also known from South America and Africa. The single Tasmanian collection is from granite outcrops in open coastal woodland-heathland.

Specimen examined
Tasmania — Mt Amos, 42°09'S, 148°18'E, 480 m, 28 July 1991, G. Kantvilas 285/91 (HO).

Lecidella elaeochroma (Ach.) M. Choisy, *Bull. Mens. Soc. Linn. Lyon* 19:19 (1950) — *Lecidea parasema* var. *elaeochroma* Ach., *Meth. Lich.*: 36 (1803)

This species was previously listed for Tasmania on the basis of collections from cool temperate rainforest, wet scrub and buttongrass moorland (Kantvilas 1988, Kantvilas & Jarman 1988). However, that material was subsequently recognised as belonging to a separate, undescribed taxon (Kantvilas 1994). Now *Lecidella elaeochroma sens.str.* is confirmed for Tasmania, where it grows on the twigs of *Hymenanthera prostrata* in alpine heathland, a habitat virtually identical to where it grows in mainland Australia (Hertel 1985). This Tasmanian material accords very closely to specimens from the Northern Hemisphere. It is characterised by the smooth to rather areolate or verrucose, pale-greyish to yellow-grey thallus, C+ orange-yellow, K+ yellowish, UV+ orange (all reactions frequently very faint); black, lecideine apothecia, mostly <0.8 mm diameter; a dark greenish-black to greenish-brown epithecium and outer excipulum edge; colourless hymenium; orange-brown hypothecium, intensifying orange in K; asci with an amyloid tholus, having a convergent masse axiale with a rather rounded apex and a distinct amyloid zone above; simple paraphyses separating easily in K; and simple ascospores, 10–17 × 6–9 µm (for further data, Purvis *et al.* 1992).

Specimens examined
Summit of Mt Wellington, 42°54'S, 147°14'E, 1200 m, 9 January 1989, M. Allen (HO); Mt Ossa, 41°52'S, 146°02'E, 1600 m, 14 March 1992, G. Kantvilas 116/92 (HO).

Neofuscelia luteonotata (J. Stein.) Essl., *Mycotaxon* 7: 51(1978)

This species is distinguished by the moderately to loosely adnate foliose thallus, the olive-brown to dark-brown upper surface, the pale-tan to pale-brown lower surface, the lack of isidia and the presence of medullary divaricatic and stenosporic acids (cortex K-, HNO_3+ dark blue-green, medulla K-, C-, KC-, P-). Its lobes are sublinear and irregularly branched, discrete to more often contiguous or subimbricate, and very rarely developing upright, subfruticose laciniae (for a full description, Esslinger 1977). Most of these morphological characters are also observed in *N. scabrosina* Elix and *N. subimitatrix* (Essl.) Essl., although the former has smaller spores (6–9 × 3.5–5.5 µm as compared to 8–10 × 5–7 µm) and the latter species tends to be more tightly adnate. These three species are distinguished most reliably by their chemistry as *N. scabrosina* contains constipatic acid, protoconstipatic acid and various scabrosin derivatives (medulla K-, C-, KC-, P-) while *N. subimitatrix* contains physodic acid (medulla KC+ rose-red).

Neofuscelia luteonotata is an occasional species on soil and rocks in southern Australia, previously reported from Victoria, South Australia and Western Australia. It is also known from southern Europe, Africa and New Zealand. *N. luteonotata* is apparently uncommon in Tasmania, where it was collected on vertical dolerite rocks in dry sclerophyll woodland.

Specimen examined
Gunners Quoin, summit area, 42°46'S, 147°20'E, 440 m, 28 April 1992, G. Kantvilas & J.A. Elix 186/92 (CANB, HO).

Paraparmelia leucophaea Elix & J. Johnst., *Mycotaxon* 32: 403 (1988)

This species is characterised by the adnate to moderately adnate foliose thalli to 9 cm wide, the brown to dark-brown lower surface, the lack of soredia and isidia, and the presence of norstictic acid and salazinic acid in the medulla [medulla K+ yellow then dark red, P+ yellow-orange; containing atranorin, norstictic acid (minor), salazinic acid (major), connorstictic acid (trace), consalazinic acid (minor)]. The lobes are subirregularly to dichotomously branched, 1–3 mm wide but occasionally developing laciniae towards the thallus centre which are narrower (0.5–1 mm wide), markedly imbricate and irregularly branched (full description, discussion and illustration, Elix & Johnston 1988).

These characters are also found in *Paraparmelia cerussata* (Kurok.) Elix & J. Johnst. but the latter is tightly adnate, has a paler lower surface and lacks salazinic acid. *P. leucophaea* is also known from southern New South Wales and eastern Victoria. This Australian endemic is apparently uncommon in Tasmania, where it was collected on ± vertical dolerite rocks and soil banks in dry sclerophyll forest.

Specimens examined
Gunners Quoin, summit area, 42°46'S, 147°20'E, 440 m, 28 April 1992, G. Kantvilas & J.A. Elix 178/92 (CANB, HO); Risdon Brook below dam, 26 April 1969, G.C. Bratt (HO).

Parmelia tarkinensis Elix & Kantvilas, sp. nov. (Pl. 2)

Species cum thallo ut in *Parmelia cunninghamii* sed ab hac specie lobis sublinearibus, angustioribus et acidum protocetraricum et acidum echinocarpicum continente differt.

Type
Sumac Road, spur 2, south of Arthur River, 41°08'S, 145°02'E, 170 m elevation, on *Tasmannia lanceolata* in rainforest, 30 January 1992, G. Kantvilas 80/92, B. Fuhrer & J. Jarman (HO — holotype; CBG — isotype).

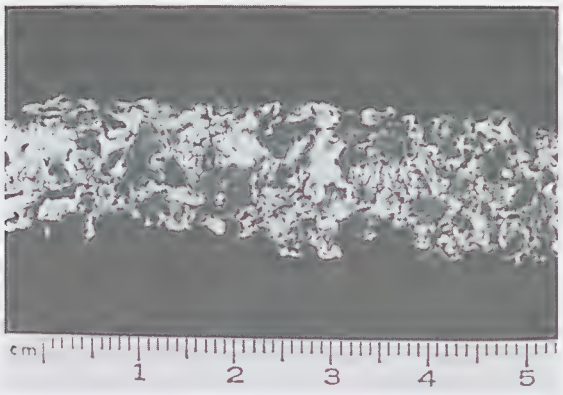

PLATE 2
Parmelia tarkinensis *(holotype).*

Thallus corticolous, firm, adnate, 2–8 cm diameter. Lobes sublinear, short, contiguous or ascending at the margins, 2–3 mm wide. Upper surface pale greenish grey to whitish grey, shiny but becoming dull and blackening with age, plane to rugose-foveolate with age, reticulately fissured only in the older parts, sorediate; soralia linear along the margins, orbicular when laminal, soredia farinose; pseudocyphellae effigurate, few, small, flecklike, mainly on the marginal lobes. Lower surface moderately to densely rhizinate, the rhizines simple to sqarrosely branched, 1–2 mm long. Pycnidia rare, marginal; conidia cylindrical, 5.5–7.0 × 1 µm. Apothecia not seen.

Chemistry
Cortex K+ yellow; medulla K+ yellow, C-, P+ orange; containing atranorin, chloroatranorin, protocetraric acid (major), echinocarpic acid (major), conechinocarpic acid (minor).

Parmelia tarkinensis has affinities with *P. cunninghamii* but is distinguished by the narrower, sublinear lobes and medullary protocetraric and echinocarpic acids. *P. cunninghamii* develops similar soralia but has broader (3–6 mm wide), irregular lobes with rotund apices and contains medullary salazinic and consalazinic acids. Chemically *P. tarkinensis* resembles *P. protosulcata* Hale (both contain protocetraric acid, but the latter lacks echinocarpic acid), but *P. protosulcata* has still narrower lobes (1–3 mm wide) which are linear-elongate and have truncate apices. In addition *P. protosulcata* has particularly coarse soredia which become partially corticate (sorediate-isidia), whereas *P. tarkinensis* and *P. cunnighamii* have fine, farinose soredia.

Parmelia tarkinensis is known only from northwestern Tasmania, where it is locally abundant in the extensive rainforest stands south of the Arthur River. Although it has also been recorded as far south as the slopes of Mt Murchison (Anthony Road), these collections are very fragmentary and there the species appears to be very uncommon. In contrast, at the type locality it is probably the most common species of *Parmelia* present.

The new species appears to be confined to cool temperate rainforest below 600 m altitude, and occurs on canopy twigs. Associated lichens include *Coccotrema cucurbitula, Menegazzia weindorferi, Parmelia protosulcata, P. tenuirima, Pertusaria truncata, Usnea oncodes* and *U. xanthopoga.*

Etymology
The specific epithet is based on the word "Tarkine", a name which has been loosely ascribed to the forest and wilderness region in the Arthur and Pieman River catchments of Tasmania's northwest.

Specimens examined
Type locality, 24 May 1981, G. Kantvilas 294/81 (CANB, HO); Arthur–Pieman Protected Area, 35 km NNE of Savage River along the pipeline road, 41°18'S, 145°16'E, 480 m, 8 December 1993, J.A. Elix 4014 & G. Kantvilas (CANB); Anthony Road, 41°49'S, 145°38'E, 480 m, 15 November 1992, G. Kantvilas 520/92 (HO); same locality, G. Kantvilas 548/92, 206/91 (HO).

Parmotrema crinitum (Ach.) M. Choisy, *Bull. Mens. Soc. Linn. Bot. Lyon* 21:175 (1952) — *Parmelia crinita* Ach., *Syn. Meth. Lich.*: 196 (1814)

Parmotrema crinitum is characterised by an adnate thallus, lobes with ciliate margins, copious cylindrical isidia which are often ciliate, and the presence of the stictic acid complex in the medulla (for description and discussion, Elix 1994b). This species is apparently uncommon in Tasmania, where it has been recorded from the bark of *Melaleuca ericifolia* and *Bursaria spinosa* in a coastal swamp. In mainland Australia, this cosmopolitan species is common in coastal areas of Queensland, New South Wales and Victoria.

Specimens examined
Robbins Island Track, just south of Denium Hill, 25 km northwest of Smithton, 40°44'S, 144°53'E, 2 m, 10 December 1993, J.A. Elix 40290 & G. Kantvilas (CANB), G. Kantvilas 128/93 & J.A. Elix (HO).

Physcia dubia (Hoffm.) Lett., *Hedwigia* 52: 254 (1912) — *Lobaria dubia* Hoffm., *Deutsch. Fl.* 156 (1796)

This species is characterised by the narrow lobes (rarely exceeding 1 mm), the grey to grey-brown upper surface, which is usually distinctly darker at the lobe apices, and the marginal labriform soralia, mostly at the lobe tips. The lower surface is whitish and rhizinate, with a prosoplecten-chymatous lower cortex, i.e. consisting of elongated hyphae in longitudinal section (for a full description, Moberg 1977, Thomson 1963). This species possesses no medullary chemistry but the cortex is K+ yellow (atranorin).

Physcia dubia is known from the Australian mainland (New South Wales and the Australian Capital Territory) and is a broadly distributed species also occurring in Eurasia, North America and East Africa. It is apparently rare in Tasmania, where it occurs on the Central Plateau on alpine and subalpine dolerite boulders manured by birds. Tasmanian specimens form rather irregular, loosely attached clumps, intermixed with *Teloschistes velifer.*

Specimens examined
Great Lake Plateau, 41°57'S, 146°40'E, 1000 m, 18 January 1969, G.C. Bratt 69124 (HO); Central Plateau, Lake Augusta Dam, 41°51'S, 146°35'E, 1140 m, 7 December 1993, J.A. Elix 40068 & G. Kantvilas (CANB), G. Kantvilas 181/93 & J.A. Elix (HO).

Physcia dubia is superficially very similar to *P. tribacia* (Ach.) Nyl., to the extent that earlier authors, for example Thomson (1963), had suggested that the two taxa may not be distinct. However, *P. tribacia* clearly differs in the

presence of a paraplectenchymatous lower cortex (seen as large isodiametric cells in longitudinal section) and also tends to have a shiny, unblackened upper surface, crenulate lobe tips and soralia which are initiated on the underside of the lobe tips (see also Purvis *et al.* 1992 for further data).

Previously recorded only tentatively from the Bass Strait islands, *P. tribacia* is here confirmed for the Tasmanian mainland. It occurs on lowland outcrops of dolerite, sandstone and granite, often in coastal areas, in dry sclerophyll forest and heathland.

Specimens examined
Mt Amos, Freycinet Peninsula, 42°09'S, 148°17'E, 21 August 1971, G.C. Bratt & J.A. Cashin 71/1275 (HO); Cataract Gorge, 41°27'S, 147°07'E, 15 July 1984, G. Kantvilas 678/84 (HO); Bradys Point, 42°32'S, 147°06'E, 300 m, 2 August 1981, G. Kantvilas 454/81 (HO, BM); Old Beach Road opposite Cadburys, 42°47'S, 147°17'E, 5 February 1984, G. Kantvilas & P.W. James 296/84 (HO, BM).

Protoblastenia calva (Dickson) Zahlbr., *Catal. Lich. Univ.* 7:1(1931) — *Lichen calvus* Dickson, *Fasc. Plant. Cryptog. Brit.* 2:18 (1789)

Protoblastenia calva is characterised by an endolithic thallus, superficial, convex, orange, K+ crimson apothecia to c. 1 mm diameter, ellipsoid spores, 8–15 x 5–8 µm, and a colourless hypothecium (Poelt & Vezda 1977). Only one other species of the genus, *P. rupestris*, is currently known from Tasmania; this species differs in having a superficial thallus and smaller apothecia.

Protoblastenia calva is widespread on limestone across the Northern Hemisphere. It appears to be rare in Tasmania, where it is known from a single collection from limestone outcrops in sedgeland.

Specimen examined
Vale of Belvoir, 41°33'S, 145°53'E, 800 m, 21 May 1993, G. Kantvilas 47/93 (HO).

Xanthoparmelia jarmaniae Elix & Kantvilas, sp. nov. (Pl. 3)

Species cum thallo ut in *Xanthoparmelia mougeotina* sed ab hac specie lobis laxe adnatis et acidum norsticticum, acidum salazinicum et acidum consalazinicum continente differt.

Type
Clifton Vale Road, 6 km west of Kempton, 42°32'S, 147°08'E, 200 m elevation; on sandstone rocks in *Eucalyptus* woodland, 11 December 1993, J.A. Elix 40356 & G. Kantvilas (HO — holotype).

Thallus foliose to subcrustose, closely appressed, 1–3 cm diameter, ± rosette forming. Lobes narrow, 0.5–1.0 (–1.5) mm wide, stellate or rarely contiguous, not at all imbricate; apices markedly incised. Upper surface pale yellow-green but darkening to yellow-brown or black in the centre of the thallus, flat to slightly concave, shining at apices, dull and irregularly cracked near centre of thallus, becoming crustose-areolate with age, isidiate; isidia small (0.1–0.2 mm), simple, cylindrical at first but moderately branched, brown-tipped, sparse to moderately dense, apices

PLATE 3
Xanthoparmelia jarmaniae *(holotype).*

syncorticate; lacking maculae and soredia; medulla white. Lower surface black to dark brown, smooth, shining, sparsely rhizinate, rhizines simple, black. Apothecia and pycnidia not seen.

Chemistry
Cortex K+ yellow; medulla K+ yellow then red, C-, KC-, P+ yellow-orange; containing usnic acid, norstictic acid (major), salazinic acid (major), consalazinic acid (minor).

In the Australian flora, *Xanthoparmelia jarmaniae* most closely resembles *X. mougeotina* (Nyl.) D. Gall., since both species have small foliose to subcrustose thalli, cylindrical isidia with syncorticate apices and a black lower surface. However, the lobes and thalli of *X. jarmaniae* are not as tightly adnate as those of *X. mougeotina*. Furthermore, the two species differ chemically with *X. mougeotina* containing the stictic acid chemosyndrome (medulla K+ yellow) rather than norstictic and salazinic acids. On other continents, only *X. minuta* Hale from South America (Hale 1986) approaches *X. jarmaniae*. The former differs in having subglobose, unbranched isidia and containing gyrophoric acid and protoconstipatic acid in addition to the substances observed in *X. jarmaniae*.

Xanthoparmelia jarmaniae is hitherto known only from the type locality, a low rainfall area (c. 500–600 mm per annum) with extensive dry sandstone bluffs and dry sclerophyll forest. This region is one of exceptional lichenological interest, supporting several species which are unknown elsewhere in Tasmania, for example *Pyxine nubila*, *Melanelia piliferella*, *X. exillima* and *X. rubrireagens*.

Etymology

This species is named in honour of our friend and colleague, Dr S.J. Jarman, in recognition of her contribution to the knowledge of Tasmanian vegetation.

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ROYAL SOCIETY OF TASMANIA
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PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA
VOLUME 129

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